

A SOIL-CROP ANALYSIS SYSTEM
(SCAS)

By

SD005-09
SYSTEMS DEVELOPMENT

DEPARTMENT OF INFORMATION TECHNOLOGY
FACULTY OF COMPUTING AND INFORMATION TECHNOLOGY

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Supervisor

Mr. Drake Patrick Mirembe

Department of Networks
Faculty of Computing and Information Technology, Makerere University
dmirembe@cit.mak.ac.ug, +256-712-844343, Fax, +256-41-540628, Fax: +256-41-540620

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Declaration

We SD005-09 do hereby declare that this Project Report is original and has not been published and/or submitted for any other degree award to any other University before.

#	Names	Registration Number	Signature
1	BAMUHIGIRE PETER	06/U/11150/PS	
2	KAMBUGU ISAAC	06/U/11181/PS	
3	SSEMUGOOMA LAWRENCE KYAZZE	06/U/11378/PS	
4	AYEBALE GRACE	06/U/11145/PS	
5	KYOMUGASHO SHEILA	06/U/11227/PS	
6	ATUKUNDA DORCAS	06/U/11143/PS	
7	HABYARIMANA PHYLLIS	06/U/11168/PS	
8	KYOLABA SOPHIE	06/U/11226/PS	

Date:

Approval

This Project Report has been submitted for Examination with the approval of the following supervisor/s.

Signed:

Date:

Mr. Drake Patrick Mirembe

Department of Networks

Faculty of Computing and Information Technology, Makerere University

Dedication

This report is dedicated to all the group members of SD005-09 who spared their little time available to make sure that this work was accomplished successfully. We further dedicate this report to our supervisor Mr. Drake Patrick Mirembe who made himself available to us whenever we needed guidance and to the love, support and hard work that our parents have endlessly invested and showed to us.

God Bless you all.

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List of Abbreviations

BCSR- Base Cation Saturation Ratio system

DBMS- Database Management System

DFD- Data flow Diagrams

ERD-Entity Relationship Diagram

FAO- Food and Agricultural Organization

HTML-Hyper Text Mark-up Language

ICT-Information and Communications Technology

PHP-Hypertext Pre-processor

SCAS- Soil-Crop Analysis System

SQL- Structured Query Language

Abstract

The use of technology in the agricultural sector is becoming more important as the demand for computer-based agricultural systems heightens world wide. Identifying directions for development of future ICT for the agricultural sector depends on understanding the context in which solutions are to be deployed.

This report gives details on several activities carried out as part of a case study, focused on the agricultural sector and drawing upon the existing local area network capability as well as interaction with agricultural professionals. Existing in-house system from different application domains were investigated for their relevance to the agricultural sector and it was realized that the soil analysis process and the storage of soil data results was manually done and slowly conducted and it further contributed to the loss of valuable soil data results, it also contributed to wrong recommendation of crops and fertilizers to farmers and therefore ; scenarios were simulated for future ICT use in the agricultural sector, based on existing literature on ICT application deployment in agricultural sector, a need to come up with an efficient, accurate system to solve the slow soil analysis process and improve on data storage of soil test results and recommendations given to farmers was made. This was achieved through designing the system which would do this. Success was registered because the system designed was able to achieve the intended objectives of the study.

Interviews and visits were carried at the faculty of agriculture to obtain their insights into ICT application in the agricultural sector. These methods gave an understanding into how to carry out future development of ICT solutions for agricultural sector. The system was designed by using DFDs and ERDs and using programming languages (PHP, HTML and MYSQL).

Chapter 1

1.0 Introduction

This project report was written basing on the research work carried on the existing soil analysis procedures with an intension of exposing their weaknesses, strength and problems. The intension was to develop a soil-crop analysis system to solve these problems identified after realizing that the soil analysis and data management in terms of storage and accessibility was poorly done. This therefore prompted the researchers to carry out an investigation on how soil analysis is carried out at the faculty of agriculture, Makerere University so that a soil-crop analysis system would be developed to handle the stated problem above.

1.1 Background

Over the past twenty years, Information and Communication Technology (ICT) has grown to achieve unanticipated levels of sophistication. The use of ICT has taken a different direction, owing to the demands and needs in various sectors of government and among the public. The utilization of ICT has ranged from astronomy, to agriculture medicine/health, to telecommunications, as well as to many other spheres. Agricultural information systems have been extensively implemented both in developed and less in developing countries.

Soil-Crop Analysis System (SCAS)

With the past reviews and analysis of some systems that have been developed and implemented overtime in the agricultural sector, our team decided to come up with an improved and modern system that is known as the Soil-Crop Analysis System (SCAS)

A soil-crop analysis system is a computer program or set of programs used to analyze results of soil tests and conditions in order to accurately pinpoint out any nutrient deficiencies, give fertilizer recommendations and suggest the most ideal crops to grow in those conditions whilst estimating the yields one can expect from growing either of those crops. Therefore Soil analysis is an aid to managing soil nutrients efficiently to maintain soil fertility for those nutrients like phosphorus (P), potassium (K) and magnesium (Mg) that are retained in soil in plant available forms.

For many years soil analysis has been used as an aid to assessing soil fertility and crop nutrient management and this has been established in the Soil Index system widely used in the world. Some alternative approaches based on the ratio of certain cations in soil (Base Cation Saturation Ratios) and the use of soil audits are being promoted as better approaches to plant nutrient management.

Today farmers are confronted with squeezing more yields from increasingly expensive and scarce resources. They are also challenged to do that while maintaining good stewardship of the land and water resources that provide their living. The key to these challenges is to balance the soil fertility and allocate soil amendments to maximize yields.

Soil sampling and analysis is the most cost-effective tool to accomplish this goal. Unbalanced fertility has a number of potentially undesirable affects. Low levels of one or more nutrients limit the potential yield; they become the limiting factor regardless of other nutrient levels in the soil. Extremely high levels of nutrients impact the environment and put to waste those fertility resources. Soil fertility analysis shows the amount of each nutrient needed to obtain desired yield goals. Ultimately, proper fertilizer application results in the best yields, saves time and money and is environmentally correct.

Achieving and maintaining appropriate levels of soil fertility is of paramount importance if agricultural land is to remain capable of sustaining crop production at an acceptable level. Among the aids to managing soil fertility, soil sampling and analysis is the first of three equally important steps in managing the nutrients required by plants. The second is the interpretation of the analytical data leading to the third step, recommendations for nutrient additions, as fertilizers or manures, to optimize crop yields while minimizing any adverse environmental impact from their application. Currently there are well tried and tested recommendations for nutrient additions to soil.

1.2 Problem Statement

Presently, soil analysis and interpretation of soil test results is paper based. This in one way or another has contributed to poor interpretation of soil test results which has resulted into poor recommendation of crops, soil amendments and fertilizers to farmers thus leading to poor crop yields, micro-nutrient deficiencies in soil and excessive or less application of fertilizers.

The system to be designed will enable researchers and farmers with a convenient tool to analyze and interpret soil test data, selecting crops as well as determining the amount of fertilizer application rates required to optimize the yield of a particular crop which has the potential to increase crop yields and results in greater profits for the farmer.

1.3 Main Objective

To develop a computer based soil-crop analysis system that analyses results of soil tests and underlying conditions in order to recommend ideal crops to be grown there, possible outcome yields and recommend the right fertilizers to be applied to the soil.

1.4 Specific Objectives

In order to achieve the expected goals, the following objectives were addressed:

- 1 To define the system requirements in order to assess information needs of various users that will enable the effective and efficient delivery of a Soil-Crop analysis system.
- 2 To determine the processes involved in testing soils and the criteria used to decide what crops can be grown in particular soils and what fertilizers need to be applied in particular soils.
- 3 To design a new prototype for the Soil-Crop analysis system that will analyze soil test results and not only give relevant recommendations on crops and fertilizers but also calculate possible yields and economic benefits from those crops.
- 4 To implement the prototype of the Soil-Crop Analysis system.
- 5 To test and validate the design using a model or prototype to determine whether the Intended functionality of the system as required by the users is achieved.

1.5 Scope of the study

In the development, study will involve the analysis, design, implementation and testing of the Soil-Crop analysis system with concern to activities carried out at the Makerere University Faculty of Agriculture. It will focus on the procedures undertaken in testing soils for agricultural purposes, and how analysis is made on the soils before decisions are made on what crops to grow there and what fertilizers to apply. It will also focus on how yields for particular crops are calculated for an area of land and the market values for the crops.

1.6 Significance

The significance of the study was to make a contribution to literature in terms of evaluating the importance of computer-based systems to the agriculture and soil in Uganda, how we can integrate them to the field activities and their impact to service delivery: both in terms of efficiency and cost. It would also be beneficial to other researchers and higher institutions that are in the process of streamlining the ragged agricultural practices through computerized systems.

Recent developments in computing and technology have made it easy and cost effective to apply technology to all sectors of life, agriculture not excluding. There is a need to develop tools that will aid in improving agricultural productivity by solving some of the problems limiting the full potential of agriculture.

The Soil-Crop analysis system project will enable researchers, farmers and scientists to apply analyze soils with the view of enabling them make decisions on the ideal crops to grow there.

It will also be able to suggest solutions to nutrient deficiencies in the soils such as what fertilizers to apply and in what quantity. This will enable farmers to make decisions that will help increase their yields when they apply the right fertilizers and grow the right crops in their soils thus providing a solution to the majority of the farmers who suffer from chronically low yields.

We also hope that the system will be an addition to previous technologies that have been developed in soil analysis and that it will supplement the already existing structures in the sector of agriculture and more specifically in crop production. The research project further enabled us (the students) to assimilate and deploy class material to real life experience.

Chapter 2

2.0 Literature Review

2.1 The Challenges Facing Agricultural Productivity

A recent report published by *The New Vision*, (2009) [1] states that Ugandan soils have run out of nutrients due to the harsh climatic conditions of hot weather and unreliable rain patterns. This has made it hard to sustain food production without using chemical fertilizers. Indeed, studies have shown that areas around the Lake Victoria basin, Bunyoro and Eastern Uganda are no longer able to sustain food production for the population that is growing at a rate of 3.6% per year; these areas moreover form the food basket of the country. There has been a significant drop in yields since the 1950s when the last soil mapping was carried out and there is a need to analyze soil samples from across the country to help provide solutions for farmers who withstand the worst of low yields.

The Food and Agricultural Organization (FAO) has identified three major challenges affecting the productivity of soils for agriculture. *FAO*, (2006) [2] summarized that;

- Declining trends in soil fertility and mining of soil nutrients due to the adoption of intensive cultivation and short duration high yielding varieties and the blanket application of plant nutrients without the benefit of proper and timely soil analysis are inadequate to sustain soil nutrient reserves or long-term, cost-effective high crop production.
- Decline in soil organic matter levels caused by Poor on-farm management, attributed to a lack of proper information and technology transmission to the farmers in some areas.
- Overuse and inefficient utilization of mineral fertilizers and the resulting deterioration of environmental quality.

Montgomery, (1999) [3] warns that we humans are stripping the Earth of its fertile soils with our archaic farming methods. Humanity has used the same farming methods since large-scale agriculture was started around 5000 years ago. These methods not only strip the soil bare of its nutrients but also leave them unable to sustain agriculture. Man should adopt more soil-friendly

approaches that instead of stripping the soil of its nutrients, add to it the right nutrients needed for efficient cultivation of crops.

Gruhn, Goletti, and Yudelman, (2000) [4] expressed concerns over agriculture's ability to feed a world population expected to exceed 7.5 billion by the year 2020. There is decreasing availability of land for crop production yet even the available land is suffering from loss of fertility and depletion of nutrients. As reserves are depleted, crop growth and productivity can be compromised. Over time, cumulative depletion can decrease agricultural production, crop yields, and soil fertility, and lead to soil degradation. Techniques to conserve and add nutrients to the soil through the application of organic or inorganic fertilizers can help to maintain and increase the nutrient reserves of the soil. However, over supply of nutrients can also be a problem, causing economic inefficiency, damage to the environment and, in certain situations, harm to the plants themselves, and to the animals and humans that consume them or products made from them. It is therefore paramount to be able to determine the precise fertilizers required for particular soils and to be able to make proper decisions on what crops to grow there in order not to deplete the soils more quickly than is necessary.

As soils become unable to supply the necessary food to humanity, it brings about a situation of where there is lack of food security. Food security designates a situation where people produce adequate quantities of food themselves or commercial activities or food aid provide the quantity of food required to feed people on the national level for an extended period. With soils lacking nutrients, and often times being mismatched with the crops being grown, food security risks are bound to threaten the world's population. *FAO*, (2003) [5] estimated the number of people who do not have enough to eat at the beginning of the new millennium (1999-2001) at 842 million.

In order therefore to meet the food demands of the ever increasing population, farmers should be able to balance crops with soil nutrients to ensure that they are growing the right crops and that the soils have the right nutrients to sustain them thus to obtain improved yields.

2.2 Soil Testing and Analysis

In agriculture, a soil test is the analysis of a soil sample to determine nutrient content, composition and other characteristics, including contaminants. Tests are usually performed to measure fertility and indicate deficiencies that need to be remedied.

Soil testing plays an important role in crop production and nutrient management. On farms that use commercial fertilizer as the main nutrient source, it is the best way to plan for profitable fertilizer applications. On livestock farms, knowing how much nutrient is present in the soil to start with is critical. Only then can a nutrient management plan be developed to properly manage both the nutrients that have been generated on-farm and any nutrients that are being imported to the property as biosolids or commercial fertilizer.

Soil testing is really a three-step process: the collection of a representative sample from each field or section, proper analysis of that sample to determine the levels of available nutrients, and use of the results to determine optimum fertilizer rates. Keeping records is an integral part of the soil-testing process; they will help determine if soil test levels are increasing, decreasing or being maintained over time.

Soil testing can be an easy, cost effective way to manage agronomic as well as horticultural soils. It tells key nutrient levels, as well as pH levels, so the producer can make the best choice when purchasing fertilizers and other nutrients.

The following are the key nutrients and chemical elements tested in normal soil tests.

2.2.1 Nitrogen (N)

Nitrogen is a key element in the soil. It encourages vegetative growth and a deficiency in nitrogen seriously hampers yields.

2.2.2 Phosphorus (P)

Although required in smaller amounts, phosphorus is important particularly for early root growth and fruiting of crops.

2.2.3 Potassium (K)

Potassium is very important to crops and is necessary for fruiting, cell division, protein synthesis as well as the formulation of sugars, starches and carbohydrates. Together with phosphorus and nitrogen, the three, commonly referred to as NPK are the most vital of all nutrients.

2.2.4 Sulphur (S)

This is also an important nutrient that is vital in the production of chlorophyll, the main ingredient of the process of photosynthesis.

2.2.5 Magnesium (Mg)

Magnesium aids in the germination of seeds as well as the production of sugars and carbohydrates.

2.2.6 Calcium (Ca)

Calcium is a structural component necessary for cell growth and division.

2.2.7 Iron (Fe)

Iron is essential for young growing plants and also for various enzyme functions. However, high amounts of iron may result in toxicity of the soil especially when it is relatively acidic.

2.2.8 Manganese, Boron and Zinc

These trace elements are vital for various metabolic functions in crops; these include but are not limited to: enzyme activity, photosynthesis, nitrogen and other nutrient metabolism, cell wall formation, flowering, pollen germination, protein synthesis among others.

2.2.9 Organic Matter

This is a measure of the plant and animal residues present in the soil. It is a reserve for many essential nutrients especially nitrogen which are released to the plants through bacterial activity. Usually darker soils are richer in organic materials and they can be obtained from compost, mulch, manure etc.

2.3 Relevance of Soil Testing and Analysis

McFarland, Provin, and Feagley, (1998) [7] state's that Soil testing is the foundation of a sound fertility management program. Soil testing can be used to estimate how much loss has occurred and predict which nutrient(s) and how much of that nutrient(s) should be added to produce a particular crop and yield. It is necessary to ascertain the nutrients available in the soil as well as those that are deficient in order to properly know what fertilizers should be applied and what crops can be grown in the soil to achieve the required yields.

FAO, (2003) [5] also adds that the promotion of appropriate agricultural production is very important due to the underlying socio-economic conditions and the economic importance of agriculture in many regions of the world, this includes soil protection (combating the loss of soil fertility and productivity), use of appropriate tools and strategies for production and the improved use of technology. Soil testing and analysis are relevant here because they aid us in the protection of soils from nutrient deficiency through identifying the lacking nutrients, and they promote appropriate agricultural production by ensuring that the crops grown in particular soils are pertinent for the given soils.

Soil testing and analysis helps to make agriculture a more productive sector and also helps to ensure environmental sustainability by promoting appropriate methods of soil use and conservation. This helps to increase the potential of agriculture as an engine of growth, which has to this date been underutilized especially in the third world countries where 75% of the world's poor live in rural areas, with agriculture as their main source of income and livelihood.

Soil tests are vital in a soil nutrient management plan which according to *Echochem*, (2009) [8] includes analyzing soil deficiencies to determine the type, application rate, application interval, and the placement of any nutrients required to optimize short and long term productivity of the soil. The availability of required nutrients, together with the degree of interaction between these nutrients and the soil, play a vital role in crop development. A deficiency in any one required nutrient or, a soil condition that limits or prevents a metabolic function from occurring can limit plant growth.

Soil testing and analysis not only help researchers and agriculturalists to make confident decisions about soil usage, but also help to determine acceptable rates of loading fertilizers into

the soil and whether environmentally unacceptable conditions are present or are likely to occur in the soil.

The benefits of soil testing and analysis are far reaching and include increased efficiency and production, conservation and proficient use of resources, overall improvement of the environment and in the long run, generation of employment and income coming from increased yields and enhanced usage of resources.

2.4 Challenges to Soil Testing and Analysis

In as much as the benefits of soil testing and analysis are to agriculture, there are various challenges which render the entire process not entirely reliable in improving agricultural yields, and conserving resources per se.

Soil samples are subject to contamination during sampling, storage and transportation. This may render the sample unreliable for any strong deductions to be made. Critical care has to be made that only clean sterilized instruments are used.

According to *McFarland, Provin, and Feagley*, (1998) [7], sampling soil from areas with different land uses, soil types, fertilization practices, or crop yields can lead to inaccurate results.

The rate of release of nutrients from organic to inorganic forms which the plants can utilize is difficult to predict since it also depends on moisture , pH, aeration etc. moreover, soil nutrients are subject to loss by leaching, fixation and nitrification.

2.5 Fertilizer Recommendations

Fertilizer recommendations are based on the results of the soil test analyses and on the nutrient requirement of the crop to be grown. Recommendations on time and method of fertilizer application are also included. Each soil testing lab has its own philosophy for making fertilizer recommendations. Two examples are:

1. Recommendations which indicate the nutrient requirements and yield potentials for optimum economic production based one or more moisture conditions of the field.
2. "Target Yield Recommendations" which indicate the nutrient requirements for a range of

various lower and higher yield potentials under the same moisture conditions. With this information the producers have the flexibility of selecting a fertilizer application rate or target yield that best suits their individual situation.

2. 5.1 Fertilizer Types

Soil amendments are made by adding fertilizer to the soil but there are different types of fertilizers. There is bulky organic fertilizer such as cow manure, bat guano, bone meal, and organic compost and green manure crops. And then there is also **chemical fertilizer** which is also referred to as **inorganic fertilizer** and is made up with different formulations to suit a variety of specified uses. Chemical fertilizer usually comes in either **granular** or **powder** form

in bags and boxes, or in liquid formulations in bottles. The different types of chemical fertilizers are usually classified according to the three principal elements, namely **Nitrogen (N)**, **Phosphorous (P)** and **Potassium (K)**, and may, therefore, be included in more than one group.

2.5.1.1 Organic And Inorganic Chemical Nitrogenous Fertilizer Types

This type of fertilizer is divided into different groups according to the manner in which the Nitrogen combines with other elements. These groups are:

- Sodium Nitrates,
- Ammonium Sulphate and ammonium salts,
- Chemical compounds that contains Nitrogen in amide form, and
- Animal and plant by products.

1. Sodium Nitrates

Sodium Nitrates are also known as Chilates or Chilean nitrate. The Nitrogen contained in Sodium Nitrate is refined and amounts to **16%**. This means that the Nitrogen is immediately available to plants and as such is a valuable source of Nitrogen in a type of fertilizer. When one makes a soil amendment using Sodium Nitrates as a type of fertilizer in the garden, it is usually as a top- and side-dressing.

2. Ammonium Sulphate

This fertilizer type comes in a **white crystalline salt** form, containing **20 to 21%** ammonia cal nitrogen. It is easy to handle and it stores well under dry conditions. However, during the rainy season, it sometimes, forms lumps. Though this fertilizer type is soluble in water, its nitrogen is not readily lost in drainage, because the ammonium ion is retained by the soil particles. The application of Ammonium sulphate fertilizer can be done before sowing, at sowing time, or even as a top-dressing to the growing crop.

3. Ammonium Nitrate

This fertilizer type also comes in white crystalline salts. Ammonium Nitrate salts contains **33 to 35%** nitrogen, of which half is nitrate nitrogen and the other half in the ammonium form. As part of the ammonium form, this type of fertilizer cannot be easily leached from the soil. This fertilizer is quick-acting, but highly hygroscopic thus making it unfit for storage. '**Nitro Chalk**' is the trade name of a product formed by mixing ammonium nitrate with about **40%** lime-stone or dolomite. This fertilizer is granulated, non-hazardous and less hygroscopic. The lime content of this fertilizer type makes it useful for application to acidic garden soils.

4. Ammonium Sulphate Nitrate

This fertilizer type is available as a mixture of **ammonium nitrate** and **ammonium sulphate** and is recognizable as a white crystal or as dirty-white granules. This fertilizer contains **26%** nitrogen, three-fourths of it in the ammoniac form and the remainder (i.e. **6.5%**) as nitrate nitrogen. Ammonium Sulphate Nitrate is non-explosive, readily soluble in water and is very quick-acting. Because this type of fertilizer keeps well, it is very useful for all crops. Application of this fertilizer type can be done before sowing, at sowing time or as a top-dressing, but it should not be applied along the seed.

5. Ammonium Chloride

This fertilizer type comes in a **white crystalline compound**, which contains a good physical condition and **26%** ammoniac nitrogen. In general, Ammonium Chloride is similar to ammonium sulphate in action.

6. Urea

This type of fertilizer usually is available to the public in a white, crystalline, organic form. It is a **highly concentrated** nitrogenous fertilizer and fairly hygroscopic. This also means that this fertilizer can be quite difficult to apply. Urea is also produced in granular or pellet forms and is coated with a non-hygroscopic inert material. It is highly soluble in water and therefore, subject to rapid leaching. It is, however, quick-acting and produces quick results. When applied to the soil, its nitrogen is rapidly changed into ammonia. Similar to ammonium nitrate, urea supplies nothing but nitrogen and the application of Urea as fertilizer can be done at sowing time or as a top-dressing, but should not be allowed to come into contact with the seed.

7. Ammonia

This fertilizer type is a gas that is made up of about **80%** of nitrogen and comes in a liquid form as well because under the right conditions regarding temperature and pressure, Ammonia becomes liquid (anhydrous ammonia). Another form, '**aqueous ammonia**', results from the absorption of Ammonia gas into water, in which it is soluble. Ammonia is used as a fertilizer in both these forms. The anhydrous liquid form of Ammonia can be applied by introducing it into irrigation water, or directly into the soil from special containers.

8. Organic Nitrogenous Fertilizers

Organic Nitrogenous fertilizer is the type of fertilizer that includes **plant and animal by-products**. These by-products can be anything from oil cakes, to fish manure and even to dried blood. The Nitrogen available in organic nitrogenous fertilizer types first has to be converted before the plants can use it. This conversion occurs through bacterial action and is thus a slow

process. This type of fertilizer is used in conjunction with quicker-acting chemical fertilizers.

2. 5.1.2 Organic and Inorganic Chemical Phosphate Fertilizer Types

The Phosphate fertilizers are categorized as natural phosphates, either treated or processed, and also by products of phosphates and chemical phosphates.

1. Rock Phosphate

As a type of fertilizer, rock phosphate occurs as **natural deposits** in some countries. This fertilizer type has its advantages and disadvantages. The advantage is that with adequate rainfall this fertilizer results in a long growing period which can enhance crops. Powdered phosphate fertilizer is an excellent remedy for soils that are acidic and has a phosphorous deficiency and requires soil amendments.

However, the disadvantage is that although phosphate fertilizer such as rock phosphate contains **25 to 35%** phosphoric acid, the phosphorous is insoluble in water.

2. Superphosphate

Superphosphate is a fertilizer type that most gardeners are familiar with. As a fertilizer type one can get superphosphate in three **different grades**, depending on the manufacturing process. The following is a short description of the different superphosphate fertilizer grades:

- **Single superphosphate** containing 16 to 20% phosphoric acid;
- **Di-calcium phosphate** containing 35 to 38% phosphoric acid; and
- **Triple superphosphate** containing 44 to 49% phosphoric acid.

Triple superphosphate is used mostly in the manufacture of concentrated mixed fertilizer types. The greatest advantage to be had of using Superphosphate as a fertilizer is that the phosphoric acid is fully water soluble, but when Superphosphate is applied to the soil, it is converted into soluble phosphate.

3. *Slag*

Basic slag is a by-product of steel mills and is used as a fertilizer to a lesser extent than Superphosphate. Slag is an excellent fertilizer that can be used to amend soils that are acidic because of its **alkaline reaction**. For slag application to be an effective fertilizer it has to be pulverized first.

4. *Bone-Meal*

Bone-meal as a fertilizer type needs no introduction. Bone-meal is used as a phosphate fertilizer type and is available in two types: raw and steamed. The **raw bone-meal** contains **4%** organic Nitrogen that is slow acting, and **20 to 25%** phosphoric acid that is not soluble in water. The **steamed bone-meal** on the other hand has all the fats, greases, nitrogen and glue-making substances removed as a result of high pressure steaming. This fertilizer is particularly suitable as a soil amendment for acid soil and should be applied either at sowing time or even a few days prior to sowing.

2. 5.1.3 Organic And Inorganic Chemical Potassium Fertilizer Types

Chemical Potassium fertilizer should only be added when there is absolute certainty that there is a **Potassium deficiency** in your garden soil. Potassium fertilizers also work well in sandy garden soil that responds to their application. Crops such as chilies, potato and fruit trees all benefit from this type of fertilizer since it improves the quality and appearance of the produce. There are basically two different types of potassium fertilizers:

- **Muriate of potash** (Potassium chloride) and
- **Sulphate of potash** (Potassium sulphate).

1. *Muriate Of Potash*

Muriate of potash is a **gray crystal** type of fertilizer that consists of **50 to 60%** potash. All the potash in this fertilizer type is readily available to plants because it is highly soluble in water. Even so, it does not leach away deep into the soil since the potash is absorbed on the colloidal surfaces.

2. Sulphate of Potash

Sulphate of potash is a fertilizer type manufactured when potassium chloride is treated with **magnesium sulphate**. It dissolves readily in water and can be applied to the garden soil at any time up to sowing. Some gardeners prefer using sulphate of potash over muriate of potash.

2.6 Existing Systems

Plant nutrition and plant to soil interactions are complex mechanisms with a number of environmental and external conditions affecting the process. There are 17 elements involved in plant nutrition, three that are supplied naturally that we have little control over and 14 that are supplied by soil and or by fertilizer applications. Therefore, it is important when interpreting soil analysis and designing a fertility program, to keep balanced nutrition and proper placement of these nutrients in mind. There are two basic philosophies in soil test interpretation used today and both have merit and solid scientific support to substantiate these philosophies.

2.6.1 The Base Cation Saturation Ratio (BCSR) system

The use of “balanced” Ca, Mg, and K ratios, as prescribed by the basic Cation saturation ratio (BCSR) concept, is still used by some private soil-testing laboratories for the interpretation of soil analytical data. According to the BCSR concept, maximum plant growth will be achieved only when the soil’s exchangeable Ca, Mg, and K concentrations are approximately 65% Ca, 10% Mg, and 5% K (termed the *ideal soil*). This “ideal soil” was originally proposed by Firman Bear and coworkers in New Jersey during the 1940s as a method of reducing luxury K uptake by alfalfa (*Medicago sativa* L.).

According to the BCSR concept, a “balanced soil” (and the Ca/Mg, Ca/K, and Mg/K ratios therein implied) is required to ensure that plants produce both maximum quantity (yield) and quality. Thus, plants grown in a soil whose exchange complex is not “balanced,” i.e., does not contain the specified Cation ratios, may have reduced yield. BCSR (“balanced soil”) concept has been widely promoted, suggesting that the prescribed cationic ratios provide optimum chemical, physical, and biological soil properties.

The BCSR (Base Cation Saturation Ratio) method is being offered in the UK to give advice on fertilizer recommendations. This system is concerned only with the four “base cations”, calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na). But in practice it is often suggested that additional analyses be carried out to provide a "soil audit". A soil audit, in addition to the cations, includes data for soil pH, organic matter, active humus, P and trace elements. The BCSR approach is also being promoted as being more in tune with the ecology of the soil and is therefore environmentally desirable. It claims that the adoption of its recommendations stimulates biological activity and good soil "condition and life". Such improvements are said to utilize soil processes to, for example, unlock and make available the nutrients in soil.

The BCSR (Base Cation Saturation Ratio) system of differentiating soils on the basis of soil analysis and likely response of crops to fertilizer additions currently provides the best practical approach to plant nutrient management. Basing fertilizer recommendations on soil analysis and the BCSR system offers considerable benefits for it ensures that nutrients are applied if needed and provides a guide to the amount required. The system aims to ensure that there is sufficient of each nutrient in readily plant-available forms to ensure optimum yields and the financial viability of the farm enterprise.

Chapter 3

3.0 Methodology

3.1 Introduction

This chapter presents the methods, techniques, individuals and tools that were used to collect and analyze data that aided in the design and implementation of the system. The system was developed through a waterfall model as one step had to be finished before one went to another unlike the spiral model and other models; this was due to specific requirements that were availed by the stakeholders at the beginning: hence the requirements and other system specifications that kept on evolving as the project matured were easier to incorporate and plan for using this model. This in turn enabled us to cope up with the schedule and other constraints with in the project.

The methodology will further detail how the various project objectives were achieved and the criterion that were used to succeed in achieving them.

3.2 Overview of Data Collection Approaches Used

3.2.1 Reading Available Literature

This involved collecting information from past research, and studying of the existing systems, both manual and computerized that are being used in soil and crop analysis at Makerere university Faculty of agriculture and elsewhere. Information about past research was collected by studying journal articles and books in relation to the topic under study. This helped us to have an insight of requirements analysis and tools that were used to develop existing Soil-Crop Analysis systems.

3.2.2 Interviews

These aided the evaluation team to capture the perspectives of project participants, staff, soil experts, agriculturalists, researchers, academicians for example Mr. David Kirya under the department of soil science, Faculty of Agriculture Makerere University and others associated with the project. In the hypothetical example, interviews with project staff provided information in the early stages of the implementation and the problems encountered. Two types of interviews

were used namely: structured and in-depth interviews. However the study preferably took the in-depth interview method due to the time limit availed by the authorities at the site and that with the in-depth, we were able to get all the answers to the questions we required there and then. This helped us in obtaining qualitative and quantitative information that enabled us to understand the opinions of the user, policies, and activities done during the process of analyzing and testing soils for crop growing.

3.2.3 Observations

The observational technique is another method whereby the study took off time to visually study the behavior of individuals and how various activities were being carried out; through this technique we managed to gather first hand data on programs, processes and systems being studied with no bias what so-ever. This further provided us with opportunities to collect data on a wide range of behaviors, to capture a great variety of interactions and to openly explore the evaluation topic that helped us in developing a holistic perspective, i.e., an understanding of the context within which the current/previous system operates(d).

In the process of data collection through observation, we directly observed the procedures and processes of obtaining a complete soil test report and how recommendations are done for crops to be grown or fertilizers to be applied on a particular soil type. This method supplemented other methods of data collection and at the same time it gave us an opportunity for verification of certain information obtained using other methods of data collection.

A sample of a data template used to store soil test results in the department of soil science which helped us in developing our system. Below is the sample of the data template.

Sample Of Soil Analysis Results Table

Lab No	Details	p H	O. M	N	Av. P	K	N a	C a	M g	Textural %ages			Fe	M n	Z n	Cu
			%ages		mg/kg	Cmoles/kg				Sa nd	Cl ay	Si lt	mg/kg			
A	Kamasu farm, 0-30cm	4.6	2.16	0.10	4.12	0.48	0.02	0.99	0.22	54.0	30.0	16.0	93.26	18.6	0.48	0.64
B	Busilo farm 0-30cm	4.8	2.34	0.11	2.39	0.23	0.03	1.54	0.34	64.0	11.0	25.0	13.16	35.6	0.76	0.64

Table: 1

3.2.4 Key Informant

This is an individual not part of the study but well versed with important facts about the problem at hand; in this case Mr. David Kiirya was consulted in order to help the team better understand the issue being evaluated and how to obtain information on tested soils from different regions. He offered expertise beyond the evaluation team and also was useful in assisting with other educational materials and guiding the team during their visits to the organization. And this also enabled us get his views and what he felt about the system that existed at that time and what he thought was appropriate for them to do their work efficiently and promptly.

3.3 System Analysis and Design

3.3.1 System Design

This was achieved by using context diagrams, data flow diagrams and Entity Relationship Diagrams. Data Flow Diagrams (DFDs) depict the broadest possible overview of the system inputs, processes and outputs which corresponds to other general model. DFD shows how data moves and changes through the system by graphical representation of the system components, processes, and interfaces between them. It also enhances communication between the users of the current system and the researchers to help validate the user requirements.

Entity Relationship Diagrams were used to visualize the system and represent the user requirements. The Entity Relationship Diagrams are used to represent entities and how they relate to one another.

3.3.2 System Analysis

This was achieved by collecting and analyzing information about soil testing and analysis from faculty of agriculture. This information was used to identify the user requirements, functional, non-functional requirements and system requirements of the new system.

3.3.3 Interface Design

Interfaces of the system were designed using HTML, PHP Language, which have appropriate tools for designing windows based forms, website forms and interfaces.

3.3.4 Waterfall Model

The waterfall model process was used to develop the system. The waterfall model is a sequential software development process, in which progress is seen as flowing steadily downwards (like a waterfall) through the phases of Conception, Initiation, Analysis, Design (validation), Construction, Testing and maintenance. Hence this guided us in the development process of the soil crop analysis system.

3.3.5 Requirements Engineering

I. Feasibility Study

This study helped us assess the applicability and importance of coming up with a sophisticated system SCAS to deal with the problems faced as mentioned earlier by the revising and correcting the failures of the soil analysis processes which were manual based. Various feasibility measures were taken to verify the need and acceptability of the new system as per discussion below.

II. Operational Feasibility

The study involved going down to the grass root level to examine how soil is tested and analyzed to recommend crops that will grow best in that soil or region and simulated a situation on how such operations would be carried out with the SCAS in existence.

Activity	Current System	SCAS(Proposed)
Record keeping	Good	Very Good
Costs	Fair Good	Very Good
Yields	Good	Very Good
Speed/Efficiency	Fair	Very Good
Easy of access to files	Fair	Very Good
Availability of results from the test	Good	Very Good
Authenticity / Confidentiality	Fair	Very Good

Table: 2

Table: 3.2, above shows the possible out come when SCAS is put into use thus making it a high priority candidate to suit the existing situation.

III. Economic Feasibility

This study involved assessing how the newly built system would be evaluated economically in-terms of costs. As discovered one of the main failures of the previous system was lack of funding as it was a manual based system. In this case, the SCAS will be given out free of charge to the faculty of agriculture as a students' initiative to the agriculture from the Faculty of Computing and Information Technology. The system will not require the users to buy annual licenses or pay for its maintenance costs.

IV. Technical Feasibility

The study aimed at showing how the SCAS will be welcomed and the readiness of the users' in-terms of ICT usage. In order to yield results at this level, the study found out that; the users of the system are trained in both elementally and intermediate computer application used basically in global communication skills. This in turn signifies that present workforce are equipped with minimal computing skills that will enable them cope up fast with simple to understand and user friendly SCAS and that the technology it intends to use is readily available on the market and free of charge since its open source.

V. Schedule Feasibility

The study further went a head to find out whether the timing of this project was right or still had to wait for the environment to mature in terms of ICT usage. Gauging from the modern world and work in other industries, else computerized systems are taking the lead and this being a digital age we definitely have no doubt about the timing.

3.4 System Implementation

System implementation was achieved using MySQL, PHP scripting language and HTML language.

The database was designed using MySQL because it is highly efficient and an effective solution for data storage and handling even in a networked environment.

Reasons Why We Chose To Use PHP And MySQL For The Project.

- They are both open source software's which implies that they are cheap to get since one can just download them from the internet.
- PHP is a rapid application development environment and is known for its ease of use.
- It enables most developers to get involved with dynamic web applications without having to learn entirely new set of functions because it is very similar to structured programming languages.
- MySQL has very fast database management system and is also easier to use than many other database systems.

Other tools for system development that were used to design other components of the system include Macromedia Dream weaver 8 a software tool used for editing HTML pages, Photoshop CSC2 and Microsoft Visio a software tool used for developing Dataflow diagrams, Context diagrams and Entity relationship diagrams.

3.5 System Testing and Integration

The model of the system developed was tested by entering test data such as crop data and fertilizer data to check whether it gave the expected output. The information entered, was captured and this was proved by retrieving it from the database. It was seen that whatever was entered in the forms, was generated as entered. The details concerning the crops and the fertilizers, all was available and therefore this made the objective for poor data storage to be accomplished.

Chapter 4

4.0 System Design and Analysis

4.1 Introduction

This chapter addresses the approach used to develop user and system requirements and also approaches used to come up with the system design that gave a conceptual solution fulfilling the requirements of the project.

4.2 System Analysis

In order to document all the end user requirements for the system (SCAS), data collected was analyzed using structured analysis approaches to rigorously specify the processes. This section includes the requirements of the new system that are categorized into: functional and nonfunctional requirements.

A requirements analysis and domain analysis are done in this section.

4.2.1 Requirements Analysis

The requirements analysis stage of system development involves collecting and analyzing information about the part of the organization that is supported by the application. This information is then used to identify the user's requirements of the new system. Identifying the required functionality of the system is very important because a system with incomplete functionality may be rendered useless to the user.

The requirements of the soil-crop analysis system are to develop;

- A web based front end for entering crop details, fertilizer details, soil details and user details.
- A web based front end for viewing crop information, fertilizer information, user information and analysis results.
- A facility to enter soil tests for analysis by the system
- A facility to calculate fertilizer amounts needed by the farmer
- A facility to calculate the estimated crop yields
- A facility to generate or produce summary reports for soil analyses

4.2.2 Functional Requirements

This project aims at developing a system which should improve on the current system with a lot of functionalities, and therefore this section provides a requirement overview of the system.

Functional requirements capture the intended behavior of the system. This behavior will be expressed as services, tasks or functions the system is required to perform. This report lays out important concepts and captured functional requirements in such a way that they can drive architectural decisions as used to validate the architecture as follows.

1. The soil-crop analysis system must have a database that can support storing and retrieving of user details, crop details and fertilizer details which will later be accessed by users who log into the system.
2. The soil-crop analysis system must have a client interface that allows privileged users such as administrators to carry out tasks such as adding/editing crop details, adding/editing fertilizer details and creating/editing user details.
3. The soil-crop analysis system must have a viewing functionality in order to allow normal and privileged users to view details of a given entity from the system database.
4. The soil-crop analysis system also must have a client interface for normal users that allows them to sign up for user accounts, enter data for analysis and calculation.
5. The soil-crop analysis system must be fully integrated to the World Wide Web and hence allow access from any internet networked terminal and web browser around the world.
6. The soil-crop analysis system must have a functionality that produces summary reports from analyses and calculations.
7. The system should be able to run free of errors on popular technical environments (e.g.: UNIX, Windows, Mac OS/2, etc) and has a modern graphical user interface (GUI).

4.2.3 Non-Functional Requirements

Non-functional requirements or system qualities were used to capture required properties of the system, such as performance, security and maintainability, etc. in other words, how well some behavioral or structural aspect of the system was accomplished.

1. **Security:** Each user is required to login in using his/her username and password. The system should login staff who has been assigned a username and password. The system

should be designed to make it impossible for any body to logon without a valid username and password. Data encryption should be employed to keep the user login name and password secret.

2. **User input validation:** If the user leaves a mandatory field blank, he/she should be prompted to enter valid data in that particular field. This prevents inserting blanks spaces, wrong data in the database which leads to dirty data.
3. **Reliability:** The system should have little or no downtime and Data, as entered, must be correctly stored in the database.
4. **Ease of use:** the general and administrative views should be easy to use and intuitive. Online help and documentation should be provided.
5. **Performance:** the system should have a quick response time and be able to handle multiple concurrent users. This means that at any given time, the application will be able to maintain the performance levels specified in server and database connection.
6. **System and browser compatibility issues:** the system should be accessible on all web browsers such as Firefox Mozilla, Internet explorer, Netscape Navigator and many others.
7. **Usability:** The system will be used by individuals of varying skill level and technical competence. The system shall be intuitive to use and have extensive online help documentation to walk users through the operations they are trying to perform.
8. **Maintainability:** The code and design need to be documented well enough and designed such that a senior project team with the same amount of academic and experience can ramp up on the project within time estimate.

Others;

- i. The newly developed system must verify and validate user input and users must be notified incase of errors.
- ii. The user interface should be appealing to the user and simple to understand with enough feedback.

4.2.4 User Requirements

It is very important to get users of the system fully involved such that the problem of change management does not arise. The stake holders who will use the system therefore were

approached during the study and were asked what they expected of the proposed system and the following were the findings;

1. A system that is easy to learn and use.
2. A system that improves on the efficiency of information storage and retrieval.
3. A system that has an element of error validation, one that prompts the user on entering unusual command or data format inconsistent with the database.
4. A system that is faster, flexible and consistent.
5. A system that restricts access to information to only authorized personnel.

4.2.5 System Interface Requirements

1. System Interfaces

Client Interface - A web based interface will be implemented to allow for the user to interact with the system. This web based interface will allow for a step by step wizard like query of information in the database based on user choices. The screen may or may not have a login depending on customer request.

Administrative Interface – This interface will be implemented to allow administrators to update, add, modify or make changes to data in the database.

2. System Requirements

These requirements are grouped into hardware requirements and software requirements and there combination will enable the system to perform as expected.

a) **Hardware requirements**

Hardware component	Minimum hardware specification
Processor	Intel Pentium 111 and above / Celeron / AMD processor 900mhz or higher.
Processor speed	800MHZ and above
Random Access Memory (RAM)	128mb (DDR/SDR) or more... and 256Mb and above
Storage / Hard disk drive space	40gb for desktop & 200gb for server class machine.
Display	VGA graphics card, with resolutions of 1024 x 768 high colors – 32bit.
Network	Network interface card / Other connection to network
Keyboard & Mouse	Working PS2 ports / USB ports

Table: 3 Hardware Requirements

b) **Software requirements**

Software	Minimum software specification
Client Operating system platform	<ul style="list-style-type: none"> • Windows 9x, NT, Me, XP, Vista • Mac OSX, Tiger, Leopard
Server Operating system platform	<ul style="list-style-type: none"> • Windows Server 2003, Vista
Application program	<ul style="list-style-type: none"> • Flash player9 or higher • Internet Explorer 6.0+ • Netscape Navigator • Firefox Mozilla.
Web server software	<ul style="list-style-type: none"> • Wamp, Apache web server
Database	<ul style="list-style-type: none"> • MySQL 3.2 + • PHP 4.0+

Table: 4 Software Requirements

4.2.6 Use Case

This technique was being used to describe the functionality of the soil crop analysis system. Each use case represents a specific flow of events in the system and therefore each description of a use case defines what happens when the use case is performed.

Use Case stakeholders include:

1. Guest
2. Administrator

Use case diagram

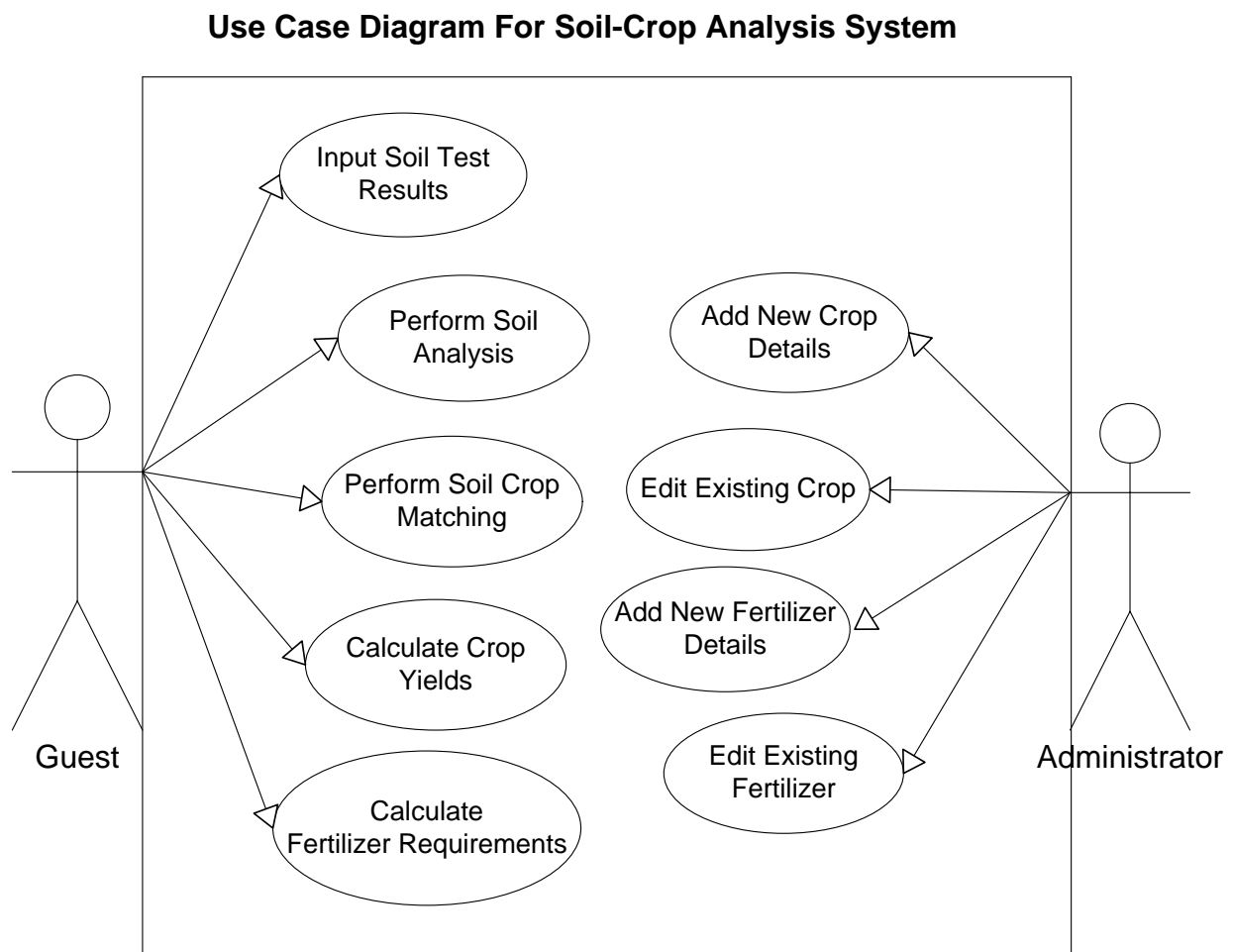


Figure: 4.1 Use Case Diagrams

Events/ Activities for Individual Use Cases

Use case name:	Administrator
Summary:	The administrator is responsible for managing the system including its database
Description:	Add New Crop Details
	The administrator adds new crop details to the system database.
	Edit Existing Crop
	The administrator can edit information of an existing crop for example entering new current prices for crops.
	Add New Fertilizer Details
	The administrator adds new fertilizer details to the system database.
	Edit Existing Fertilizer
	The administrator edits information of an existing fertilizer in the system for example entering new current prices for fertilizers.
Use case name:	Guest
Summary:	The Guest is the Farmer or Researcher who accesses the system and enters soil test results into the system to carry out soil analysis, soil-crop matching, yield calculation and fertilizer calculation.
Description:	Soil Test Analysis
	The Guest enters results of soil tests into the system to perform a soil analysis.
	Fertilizer Calculation
	The Guest uses this tool to calculate his/her fertilizer requirements by entering test results and the other required information.
	Yield Calculation

	The Guest uses this tool to calculate the yields of the selected crop from the system.
	Soil-Crop Matching Tool
	The Guest enters the Characteristics of his/her soil sample into the system to see matching crops for his/her soil sample.

Table: 5 Activities for Use Case

4.2.7 Domain Analysis

This section was used to itemize the domain or key classes in the system. In order to succeed in this part, the following were considered: system specifications and the Use Cases, along with their relationships to each other.

To clearly describe the dynamic behavior of the domain classes, the study used a dynamic representation of these sequences called: the sequence diagram. In this case, the basis for the sequence diagrams were the Use Cases, where each of the Use Cases has been described with its impact to the domain classes, to illustrate how the domain classes collaborate to perform the Use Case inside the system; however new operations were discovered and added to the classes while modeling the sequence diagram.

A Sequence Diagram for the Retrieve/Check for member data use case of the SCAS.

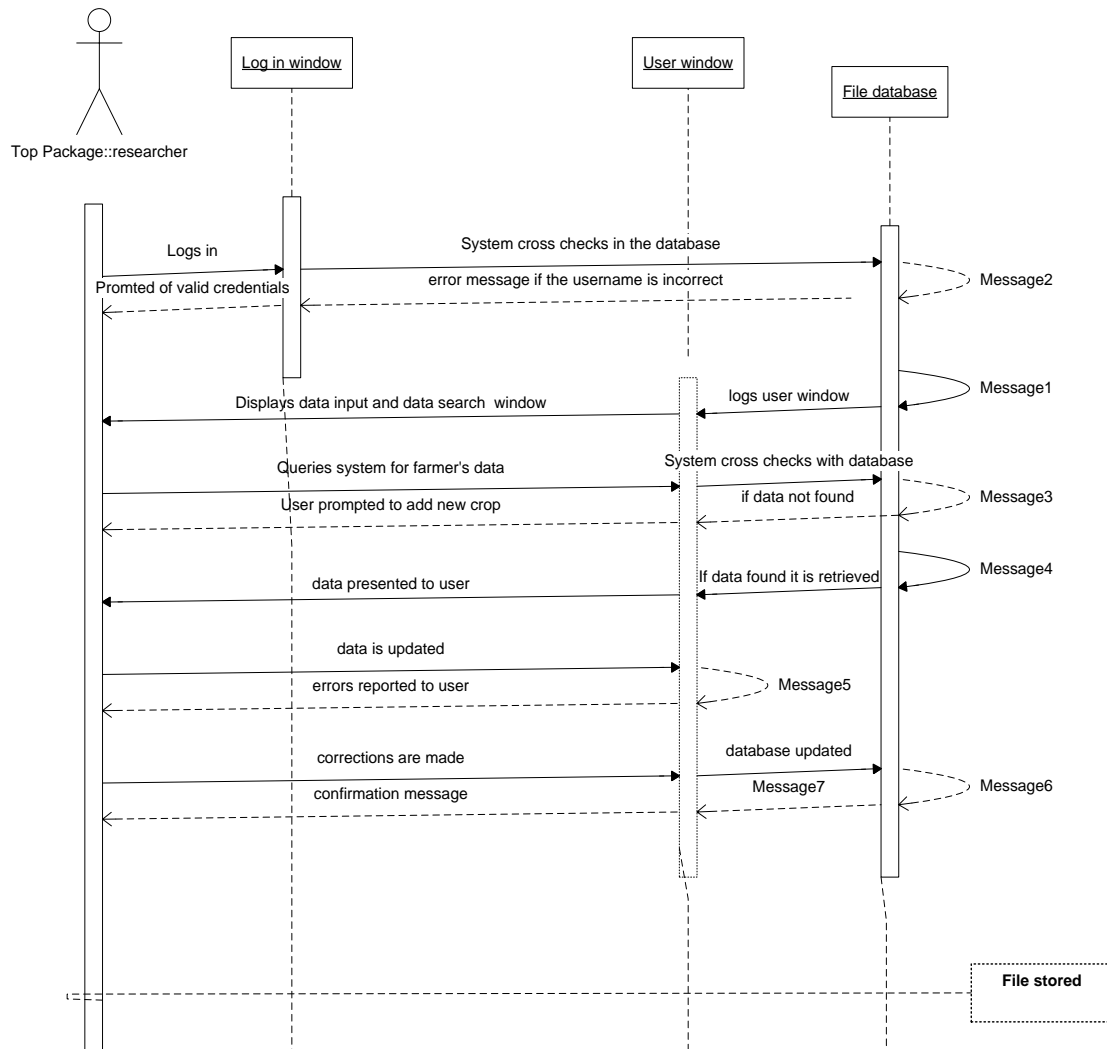


Figure: 4.2 Sequence Diagram

In summary the goals for this analysis are to achieve a communication between the user/farmer/researcher and create an understanding of the system that was built.

4.3 System Design

In the design phase, the result of analysis was expanded into a technical solution. The study used Data Flow Diagrams (DFD) and Entity Relationship Diagrams (ERD) for the process of data modeling. DFDs' were also used to show the logical flow of data and to represent processes in the system. This helps give a graphical representation of the system's components, processes and interfaces. ERD was the main tool for data modeling and was used to model relationships between the different identified entities.

The newly built Soil-Crop Analysis System is a database driven system that includes a search module for quick records retrieval. This sub section will describe in detail the system design, with use of different tools like context diagrams, different levels of DFDs, ERDs, system architecture and database design.

4.3.1 Context Diagram (Data Flow Diagrams)

A Context Diagram is the very first Data Flow Diagram that you make. A Context diagram has:

- One Process - the name of the process is the name of the system (soil-crop system)
- No Data Store
- One or more External Entities
- Two or more Data Flows

Therefore there is only one process which represents the entire system. Since there is only one process, there are no data flows between processes. Since the data store is hidden inside the system boundary, the data store is not shown.

We named the Process after the System name, and have numbered the Process '0'. The Process numbers start from zero and the Process given in a Context Diagram is ALWAYS numbered zero.

Data flow diagrams are a network representation of a system. They are the cornerstone for structured systems analysis and design. The diagrams use four symbols to represent any system at any level of detail. The four entities that must be represented are:

Data flows - movement of data in the system

Data stores - data repositories for data that is not moving

Processes - transforms of incoming data flow(s) to outgoing data flow(s)

External entities - sources or destinations outside the specified system boundary

The diagram below shows the message flow components used in a Data Flow Diagram.

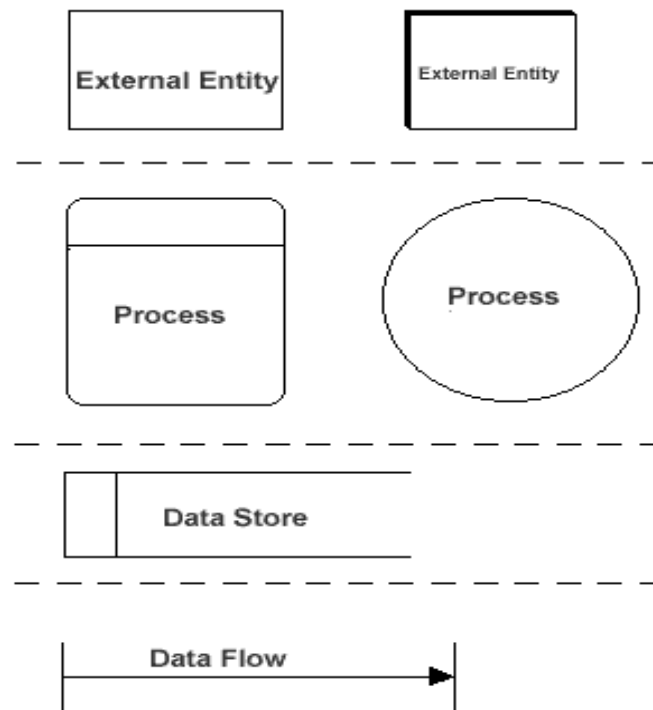


Figure: 4.3 Data Flow Diagram Components

As a group, we identified Entities and Data flows while discussing the Requirements Modeling Phase and we categorized ALL the system Requirements into 5 categories. Input, Output, Process, Performance, Controls. So we looked at the Requirements that were identified as belonging to Input/output categories. All the inputs and outputs became our data flows. Since an input has to come from some where and an output has to go somewhere - we needed to figure out the sources of inputs and the destinations of the outputs. These sources and destinations would become our Entities. Therefore the Inputs and outputs are :

Registration Form, User account, Crop details, Fertilizer details, User details, Soil test results and Analysis results

Based on the above Inputs and Outputs three Entities were identified: Guest, Member and Administrator. Below is our Context Diagram:

Soil-Crop Analysis Context Diagram

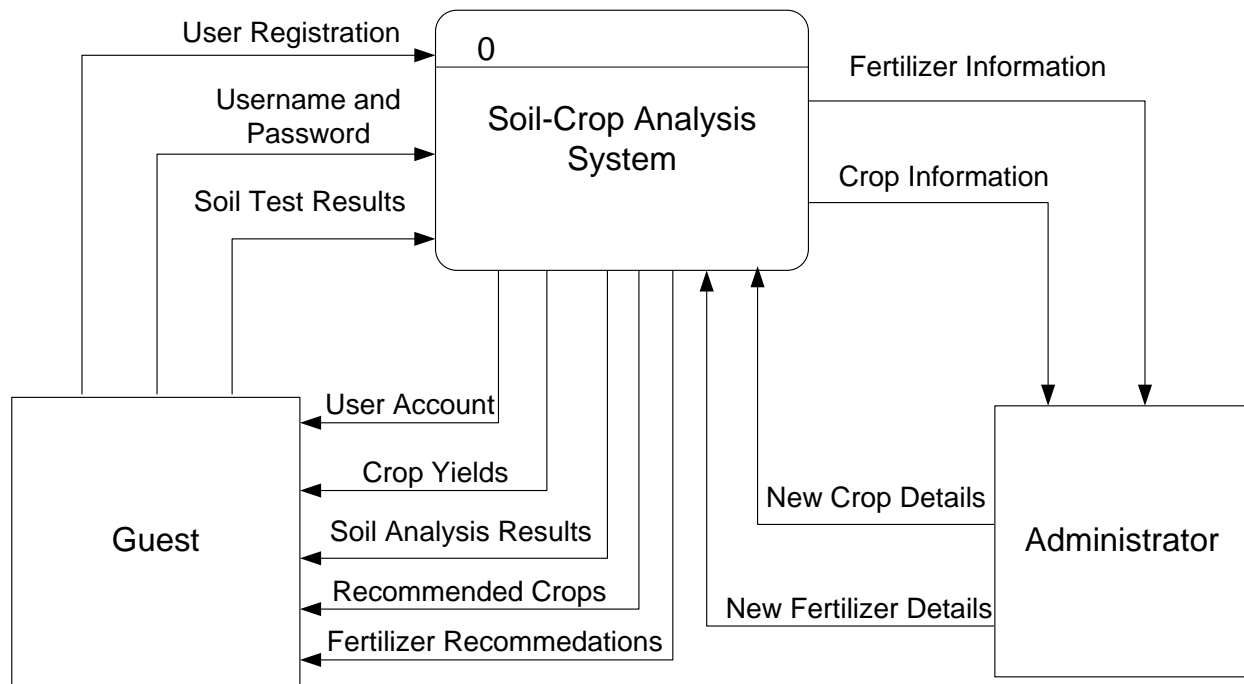


Figure: 4.4 Soil Crop Analysis Context Diagram

Data flow diagrams do not show decisions or timing of events. Their function is to illustrate data sources, destinations, flows, stores, and transformations. The capabilities of data flow diagramming align directly with general definitions of systems. Data flow diagrams are an implementation of a method for representing systems concepts including boundaries, input/outputs, processes/sub processes, etc. Below is our Data Flow Diagram:

A Data Flow Diagram For Soil-Crop Analysis System

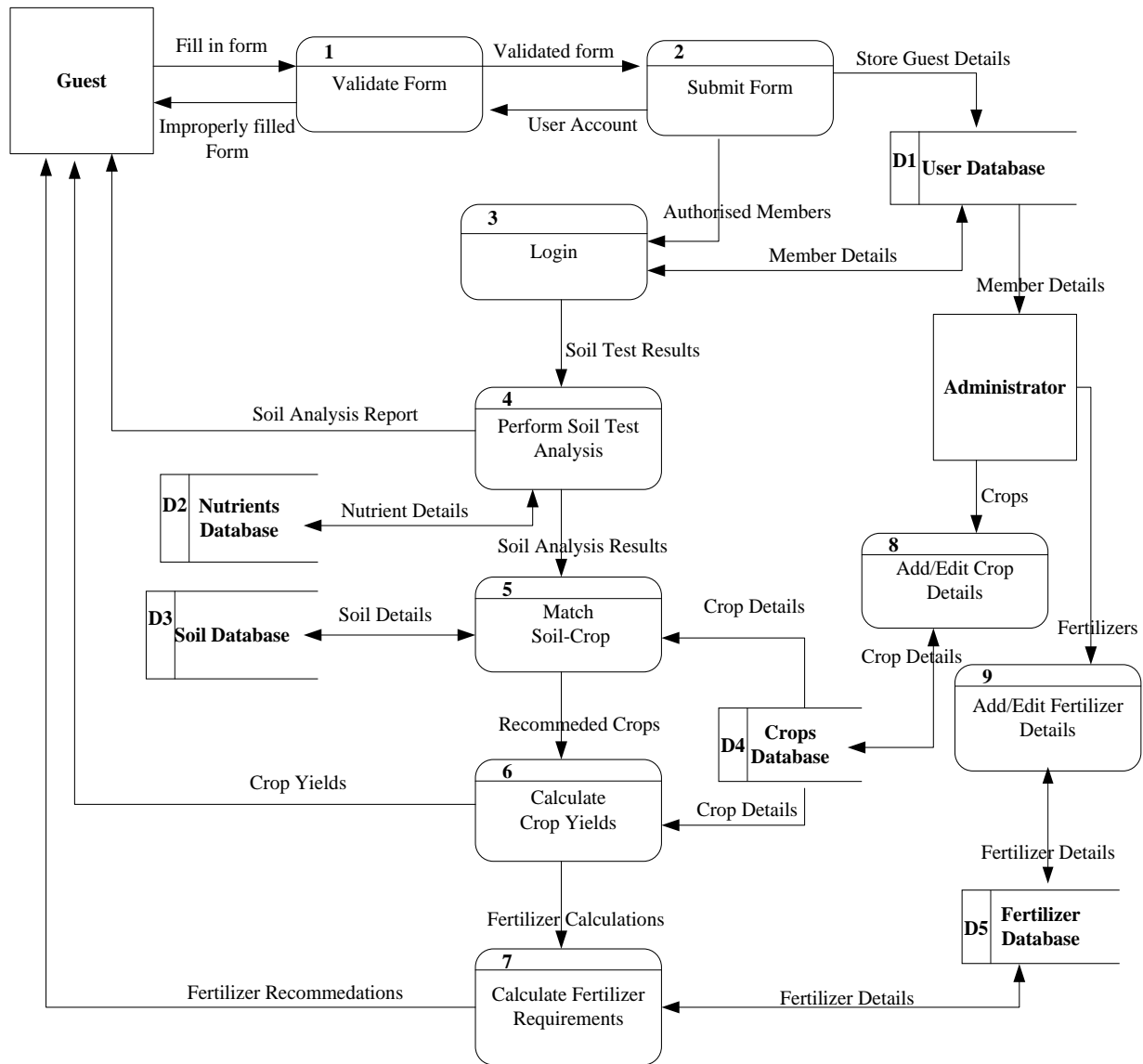


Figure: 4.5 Soil Crop Analysis Data Flow Diagram

4.4 Task Structure Diagrams and Architecture Design

For the development of a more consistent and effective system, it was essential to first identify which information should be included. To accomplish this, it was of great significance to group all the relevant tasks (system functionality) depending on the users.

4.4.1 Ordinary System User (Guest)

When an ordinary system user has successfully logged into the system via the home page login facility, it will be necessary for the system to display a specific menu with all available options that can be carried out. Therefore by taking into account of the system requirements, it will be necessary to include options such as soil test analysis, soil-crop matching tool, fertilizer analysis calculator, crop yield calculator, crop information and fertilizer information. A logout option on the user's home page enables the user to end hi/her session when desired. The diagram below shows ordinary system user's options displayed on his/her home page.

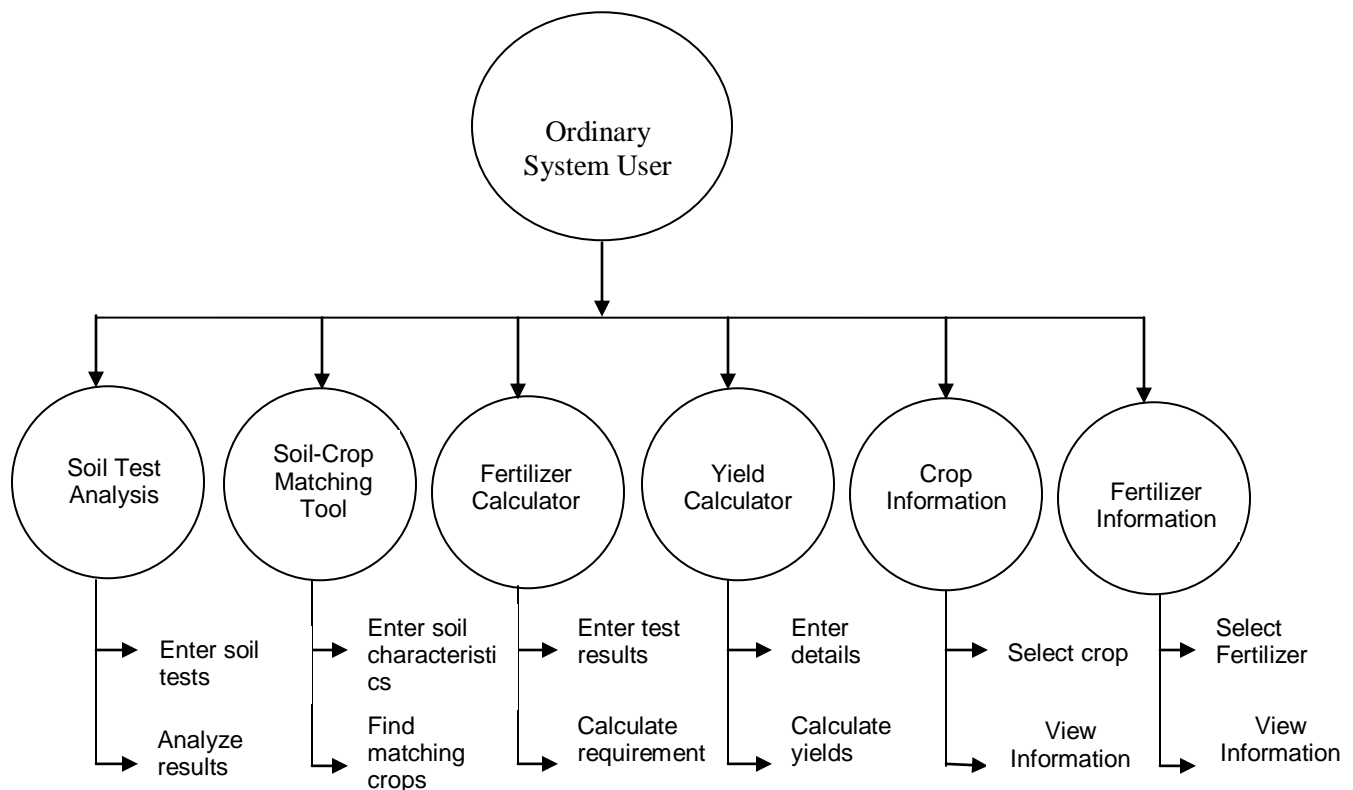


Figure: 4.6 Ordinary System User.

4.4.2 System Administrator

For maintenance purpose it was very important to include advanced administrative functionalities that can only be accessed by a particular user group. The most reasonable options for an administrator to perform his/her tasks include creating/editing user profiles, add/edit crop details, add/edit fertilizer details, view user, crop and fertilizer information. He/she is responsible modifying and maintaining the data in the system database. The diagram below shows system administrator's options displayed on his/her home page.

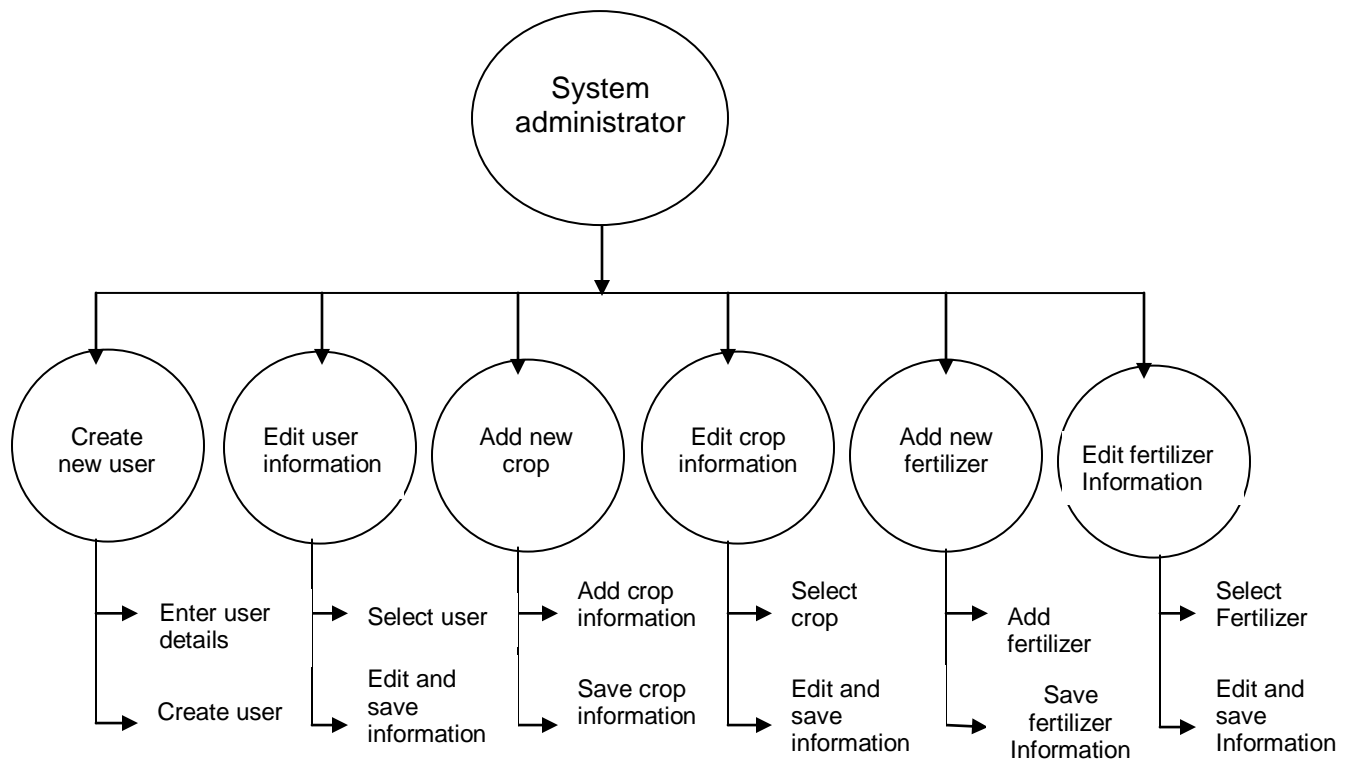


Figure: 4.7 System Administrator

4.4.3 Architecture Design

A well designed architecture is the foundation of an extensible and changeable system. The study found it vital to separate the application logic from the technical logic so that changes in either of these segments can be done easily without too much impact on the other part.

System Architectural Design

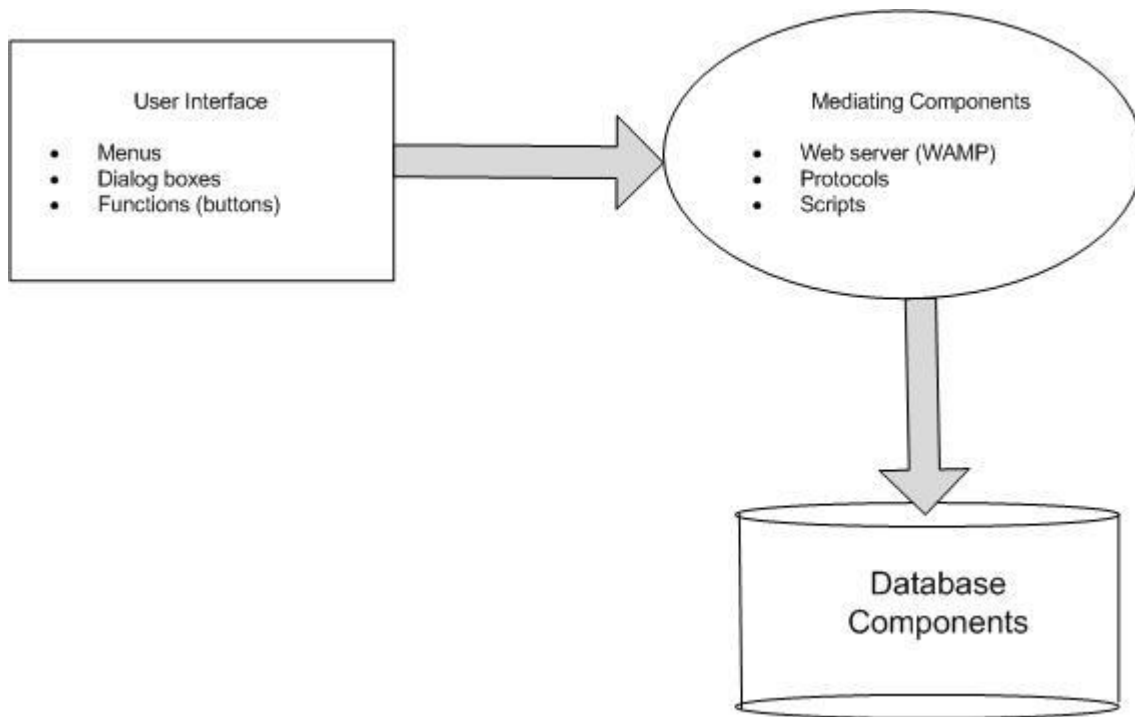


Figure: 4.8 System Architectural Design

4.4.3.1 User Interface Module

This includes classes from the entire user interface to enable users to view data from the system and to enter new data. These classes are based on HTML, and Macromedia Flash. The user interface module cooperates with the database module through PHP scripts. In this manner, the User interface calls operations that retrieve and insert data into the database.

The user interface in the SCAS is based on the use case, and was divided into the following sections; each of which supplements the system:

- **Functions:** Windows for the primary functions in the system; that is inserting and returning items and creating new files.
- **Information:** Windows for viewing the information in the system, the collected information about patients and staff.
- **Maintenance:** Windows for maintaining the system, that is: adding, updating and removing entries from the system.

4.4.3.2 Database Module

The application must have objects stored persistently; therefore a database layer was added to provide this service.

However details about the storage are hidden from the application, which has to call the common operations such as: insert (), update (), delete (), alter () and many others.

4.5 Database Design

The database design involves production of a model of the data to be stored in the database. A data model is a diagram of the database design that documents and communicates how the database is structured. The database design methodology followed in this project was suggested by Connolly & Begs (2003).

The design process is divided into three main stages-Conceptual, Logical and Physical database design. The purpose of the conceptual database design is to decompose the design into more manageable tasks by examining user perspectives of the system; that is the local conceptual data model representations of the enterprise as seen by different users.

4.5.1 Conceptual Database Design

This design phase details the various database entities and how they relate to each other through a UML tool like enhanced entity relationship diagram (EERD).

An ERD diagram is used to visualize the system and represent the user requirements. The Entity Relation is used to represent entities and how they relate to one another. The Entity Relation also shows the relationships between the entities, their occurrences (multiplicities) and attributes.

ERD Diagram For Soil-Crop Analysis System

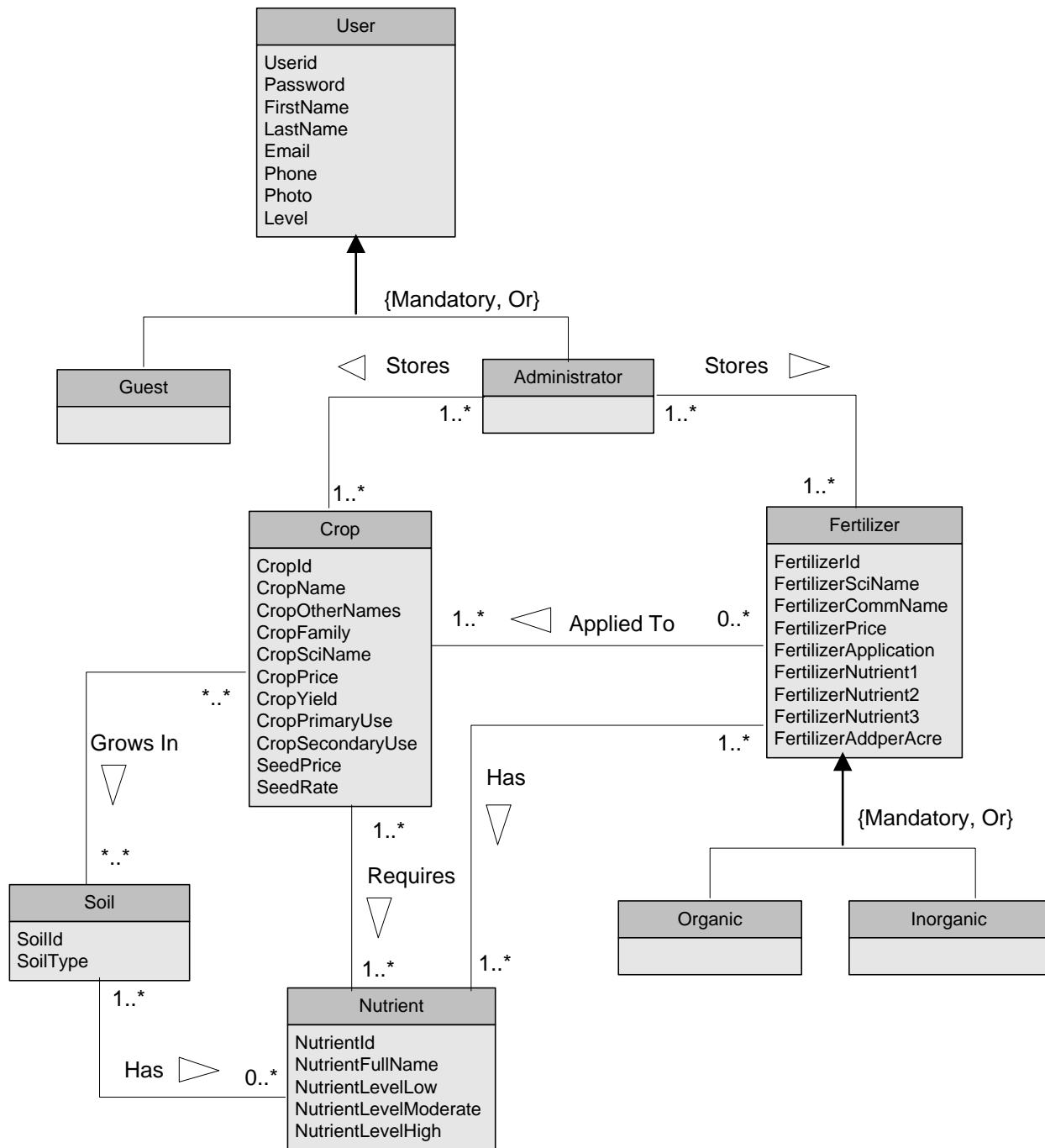


Figure: 4.9 ERD Diagram

4.5.2 Logical Database Design

This sub section shows how the above database conceptual design is finally implemented into logical relations that are understood by the computer. The process of logical database design constructs a model of the information used in an enterprise based on specific data model such as the relational model, but independent of a particular DBMS and other physical considerations (Connolly & Begs, 2003). The logical design consists of an ERD diagram, a relational schema, and any supporting documentation for them.

Producing a logical data model involves normalization. The aim of normalization is to eradicate certain undesirable characteristics from a database design. Integrity constraints are imposed in order to protect database from becoming inconsistent.

The logical design is however achieved through the data definition language, by the use of statements like: create table/database, insert into.

An illustration of how a create statement was used in MySQL databases:

- CREATE DATABASE [name];
- CREATE TABLE Crop (
crop_ID varchar(40) not null PK,
cropName varchar(40) not null,
cropFamily varchar(30) not null,
cropOthernames varchar(40) not null
);

4.5.3 Physical Database Design

Physical database design model translates the logical data model into a set of SQL statements that define the database for a particular database system. It describes the base relations, the storage structures and access methods used to access the data effectively along with associated integrity constraints and security measures. The target DBMS in this case is MySQL.

The following translations occur;

1. Entities become tables in MySQL database

2. Attributes become columns in the MySQL database
3. Relationships between entities are modeled as foreign keys.

The dictionary contains all data definitions for cross-referencing and for managing and controlling access to the information repository/database. It provides a very thorough interface description that is independent of the model itself. Changes made to a model may be applied to the data dictionary to determine if the changes have affected the models interface to other systems. Without a data dictionary, however, a database system cannot access data from the database. Below is a diagram of a data dictionary for soil crop analysis database;

A Data Dictionary For The Soil Crop Analysis Database

Entity Name	Field	Descriptions	Data Type and Size	Null
Crops	- CropId	-crop identity number	-Varchar (40)	-No
	- CropName	-crop name	-Varchar (40)	-No
	- CropOtherNames	-other names of the crop	-Varchar (30)	-No
	- CropFamily	-family group of the crop	-Varchar (30)	-No
	- CropSciName	-scientific name of the crop	-Varchar (40)	-No
	- CropPrice	-price of the crop	-decimal (10,2)	-No
	- CropYield	-estimated yield of the crop	-decimal (10,2)	-No
	- CropPrimaryUse	-major use of the crop	-Varchar (30)	-No
	-CropSecondaryUse	-other uses of the crop	-Varchar (30)	-No
	- SeedPrice	-price of the seeds in Kg's	-deciaml (10,1)	-Yes
	- SeedRate	-seed application rate	-decimal (10,1)	-Yes
Fertilizer	-FertilizerId	-fertilizer identity number	-Varchar (10)	-No
	-FertilizerSciName	-fertilizer scientific name	-Varchar (30)	-No
	-FertilizerComName	-common name for fertilizer	-Varchar (30)	-No
	-FertilizerPrice	-price of the fertilizer	-decimal (10,0)	-No
	-FertilizerApplication	-application rate of fertilizer	-Varchar (50)	-No

	-FertilizerNutrient1 -FertilizerNutrient2 -FertilizerNutrient3	-nutrients contained in a particular fertilizer. Three options were provided i.e. 1,2,3	-Varchar (3) -Varchar (3) -Varchar (3)	-No -No -No
Nutrient	-NutrientId -NutrientFullName -NutrientLevelLow - NutrientLevelModerate -NutrientLevelHigh	-nutrient identity number -nutrient name -level of nutrient (low) -level of nutrient (moderate) -level of nutrient (high)	-Varchar (3) -Varchar (30) -decimal (10,2) -decimal (10,2) -decimal (10,2)	-No -No -No -No -No
Users	-UserId -Password -FirstName -LastName -Email -Phone -Photo -Level	-user identity number -password of the user -first name of the user -last name of the user -email of the user -phone of the user -photo of the user -specifies the type of the user	-Varchar (20) -Varchar (10) -Varchar (25) -Varchar (25) -Varchar (50) -Varchar (14) -int (11) -int (11)	-No -No -No -No -No -No -Yes -No

Table: 6 A Data Dictionary

4.6 Graphical User Interface Design

4.6.1 Interface Design

Interface design encompasses three distinct but related constructs-Usability, Visualization, and Functionality by Vertelner, Arent and Lieberman (1990). Recently a fourth component of the interface design has emerged as critical factor and it is known as Accessibility. Interface design is associated with the development and designing of web pages and interfaces of systems.

- Usability: refers to how easily your media item is navigated and processed (flow, sequence and instructions).
- Visualization: is creating visually interesting and aesthetically pleasing media items while avoiding potentially distracting content.
- Functionality: refers to features of your media item and how useful they are for supporting a given task.
- Accessibility: it refers to tools that help users access your site in alternative formats (such as text, visual) which provide for increased functionality.

The user interfaces consist of various windows that enable different categories of users to interact with the system. The forms were developed using HTML and PHP. Different forms were developed to enable the users perform the following tasks;

- Register with the system that is for the new users who want to use the system.
- Login into the system
- Capturing crop information
- Capturing fertilizer information
- Viewing crop information
- Viewing fertilizer information
- Calculating crop yields
- Calculating fertilizers
- Editing/modifying crop information
- Editing/modifying fertilizer information
- Editing/modifying user information

4.6.2 Utility Module

This module contains services that ensure consistence and user input integrity to the system. This is achieved through programming languages which cross checks user input and helps in its validation according to the required data.

4.7 Formulas Used In The System Design

1. Formulae To Calculate And Analyze Nutrients In A Soil Test

x = a given nutrient

nt = value obtained from soil test for a **x**

nl = the value in a soil test which indicates a low proportion of **x** in the soil

ml = the value in a soil test which indicates a moderate proportion of **x** in the soil

hl = the value in a soil test which indicates a high proportion of **x** in the soil

if nt <= nl then amount of **x** in soil sample is **low**

if nt <= ml then amount of **x** in soil sample is **moderate**

if nt <= hl then amount of **x** in soil sample is **high**

if nt > hl then amount of **x** in soil sample is **very high**

2. Formulae To Match Crops With Soil

The formula for calculating and analyzing nutrients is used to get the proportions of each of the major nutrients this analysis returns values of high, low, or moderate.

A given pH range is calculated as follows.

pHT = value of the pH in the given soil

pHT1 = **pHT** - 0.5

pHT2 = **pHT** + 0.5

This creates a range of pH between **pHT1** and **pHT2**

The rainfall range is calculated as follows.

rainT = the annual rain of the area the test was carried out

rainT1 = **rainT** - 100

rainT2 = **rainT** + 100

This creates a range between **rainT1** and **rainT2**

The formula then returns crops from the database whose nutrient requirements for the major nutrients are equivalent to or less than the levels of the respective nutrients found in the soil test, and whose required pH lies between **pHT1** and **pHT2** and whose required annual rainfall is between **rainT1** and **rainT2**.

3. Formula To Calculate Yields.

Yields are calculated using a multiplier that is derived as follows.

ratioN = the ratio of nutrients in the soil to nutrients required by the particular crop

ratiopH = The ratio of the pH of the soil to the pH required for that particular crop

ratioOM = The ratio of organic matter found in the soil to organic matter required by the crop.

ratioSM = The ratio of the soil moisture in the soil to that required by the crop

ratioRain = The ratio of the rain of the area to that required by the crop

ratioSoil = A ratio obtained by comparing the soil texture of the soil to the soil texture required by the crop.

ratioSoil

If the soil lies within the family of soils which the crop requires, it returns a ratio of 0.75 e.g. the crop may require Clay-Loams while the soil test returns a Sandy-Loam. If the soil texture is exactly the same as required by the crop, it returns 1. If they belong to different families of soils e.g. Silty Clay and Sandy Loam, it returns 0.5.

ratioRain

It is a ratio determined by getting a range for the rainfall which the particular crop requires. If the soil test area has a value higher or lower than the range, it returns a ratio of 0.3. if it falls within the same range, it returns 1.

ratioN

ratios for the four nutrients are calculated as follows;

tn = the value found in the soil test

cn = the value of a soil test that indicates the presence of a nutrient which is sufficient for a particular crop. E.g. crop X might require a moderate level of Nitrogen which is confirmed as being present in moderate amounts in the soil if the soil test returns a value of 16% for it.

vhn = the value of a soil test for which a particular nutrient may be confirmed as present in very high amounts.

if tn <=vhn then

{ return **tn/cn** }

else {return 0}

After these ratios are calculated we get the multiplier by the following formula

$$\text{multiplier} = \frac{\text{ratioN} + \text{ratioOM} + \text{ratioSM} + \text{ratioRain} + \text{ratioPH} + \text{ratiosoil}}{6}$$

6

The crop yields are calculated by ;

$$\text{multiplier} * \text{area(in acres)} * \text{standard yields in kg for the crop}$$

4. Formula For Calculating Fertilizer Requirements

The Soil test is analyzed using the formulas in (1) above. For each of the nutrients where the analysis returns low or not-present, fertilizers are retrieved from the system which match the nutrient. For each of the fertilizers the following formulae is used.

rate = Fertilizer application rate

area = Area of land in acres

price = unit cost for fertilizer(UGX/Kg)

$$\text{requiredfertiliser} = \text{rate} * \text{area}$$

$$\text{fertiliserexpense} = \text{requiredfertiliser} * \text{price}$$

Chapter 5

5.0 Implementation

5.1 Introduction

This chapter shows the final results of the system with some screen shots and descriptions of features.

System implementation was achieved using MySQL for database designing. PHP scripting language and HTML were used to develop the interfaces and codes that link up the system interfaces and the database. The interfaces help users to input data or retrieve information from the system. They act as means of communication between users and the system. The user interfaces consist of various windows that enable different categories of users to interact with the system.

5.2 Soil Test Analysis

The screenshot displays the 'SOIL-CROP ANALYSIS SYSTEM' web application. The header features a banner with agricultural images and the tagline 'Providing solutions to farmers'. A navigation bar includes links like Home, Soil Test Analysis, Fertiliser Calc, etc. The main content area is titled 'Soil Test Analysis' and contains a form for entering soil test results. The form includes fields for Location of Soil (busiro), Annual Rainfall (Wakiso), Soil Texture (Sand 30, Silt 40, Clay 30), Nitrogen (25), Phosphorous (35), Soil pH (7.8), Soil Organic Matter Content (6.8), Total Area of Land (5 acres), Specified Mean Annual Rainfall (907 mm), Sulphates (25 mg/kg), Potassium (100 mg/kg), and Soil Moisture Content (23%). A 'Calculate Requirements' button is at the bottom of the form. The footer shows the copyright notice '© 2009 Faculty of Computing and IT Makerere University Kampala' and an 'About Us' link.

Soil Test Analysis .	
Please enter the results of your soil tests to have them analysed.	
Location of Soil :	busiro
Annual Rainfall (Select District)(mm) :	Wakiso
Soil Texture (%) :	Sand 30 Silt 40 Clay 30
Nitrogen (%) :	25
Phosphorous (mg/kg) :	35
Soil pH :	7.8
Soil Organic Matter Content(%) :	6.8
Total Area of Land (acres) :	5
Specified Mean Annual Rainfall (mm) :	907
Sulphates (mg/kg) :	25
Potassium (mg/kg) :	100
Soil Moisture Content (%) :	23
<input type="button" value="Calculate Requirements"/>	

Figure: 5.1 Soil Test Analysis

The *figure 5.1* above shows how soil that has been inputted is analyzed to tell the soil minerals, and other components that will favor the growing of a particular crop. The user fills in the required information in the textboxes that is soil test results (results from soil sampling and testing). After filling in the information, the user clicks ‘calculate requirements’ button to analyze the soil as seen in **figure: 5.2** below.

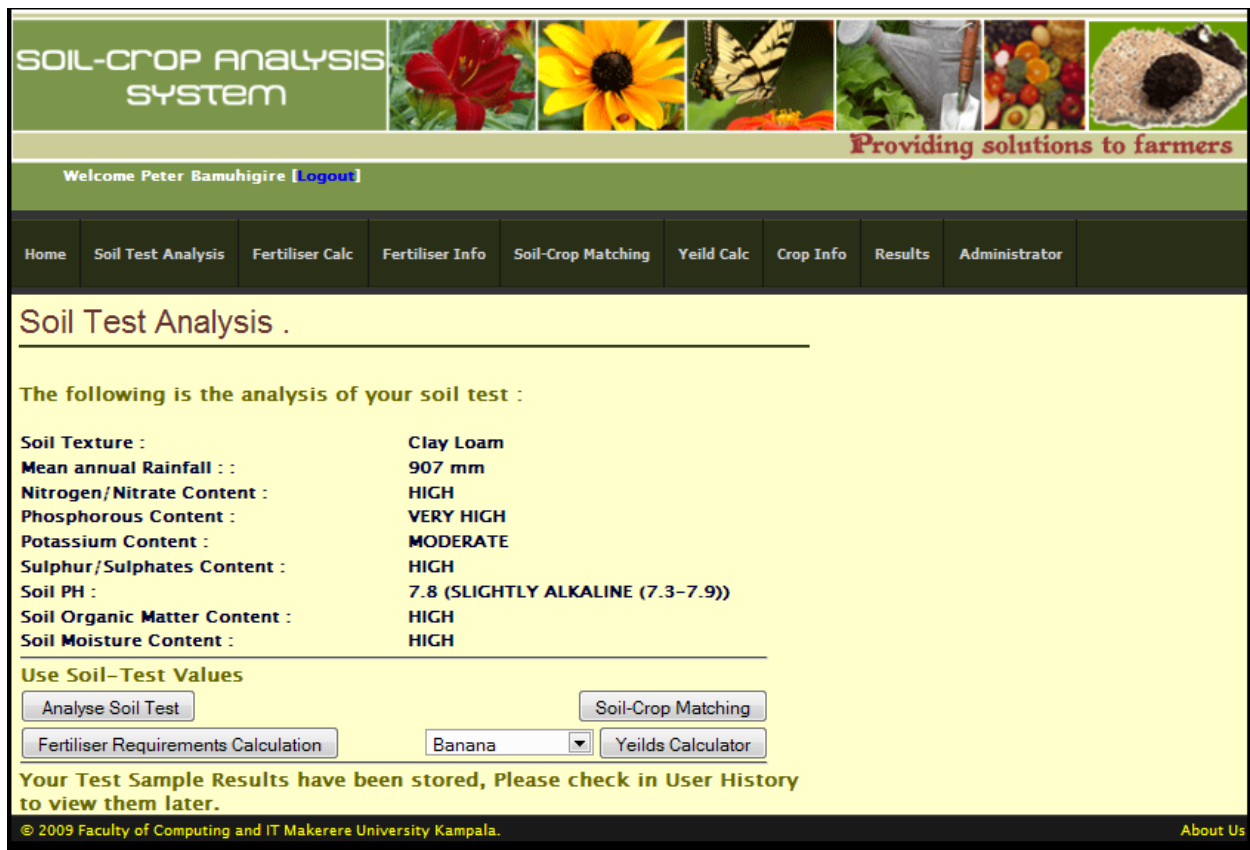


Figure: 5.2 Soil Test Analysis Results

The *figure 5.2* above shows the analysis of the soil test results entered in **figure: 5.1** above. It gives the analysis of the soil texture, nitrogen, phosphorous, potassium content, sulphur content, soil PH, soil organic matter content and soil moisture content. It compares the entered results with data stored in the system in order to determine for example whether the soil PH is Alkaline, Acidic or Neutral. On the same page, the user is provided with other options such as soil-crop matching where by the user is in position to use the same soil test results to carry out soil-crop matching.

5.3 Soil Crop Matching Tool

The screenshot displays the 'SOIL-CROP ANALYSIS SYSTEM' web application. The header includes a navigation bar with links: Home, Soil Test Analysis, Fertiliser Calc, Fertiliser Info, Soil-Crop Matching (active), Yelid Calc, Crop Info, Results, and Administrator. Below the navigation bar, a welcome message reads 'Welcome Peter Bamuhigire [Logout]'. The main content area is titled 'Soil-Crop Matching Tool.' and contains a form for entering soil characteristics. The form fields are as follows:

Field	Value
Location of Soil :	kasiku
Annual Rainfall (Select District)(mm) :	Uganda Only. Please specify for others
Soil Texture (%) :	Sand 30, Silt 40, Clay 30
Nitrogen (%) :	25
Phosphorous (mg/kg) :	35
Soil pH :	6.3
Soil Organic Matter Content(%) :	7.8
Total Area of Land (acres) :	3.02
Specified Mean Annual Rainfall (mm) :	1200
Sulphates (mg/kg) :	25
Potassium (mg/kg) :	100
Soil Moisture Content (%) :	32.5

A 'Calculate Requirements' button is located at the bottom of the form. The footer of the page includes the copyright notice '© 2009 Faculty of Computing and IT Makerere University Kampala.' and a link to 'About Us'.

Figure: 5.3 Soil Crop Matching Tool

The *figure 5.3* above shows a soil crop matching tool. The tool matches crop characteristics and requirements of crops stored in the system with the soil test results entered into the system by the researcher/farmer.

The user fills in the required information in the textboxes provided. For example the above form has been filled with soil test results by the farmer/researcher, when he/she clicks 'Calculate Requirements' button, the system matches the soil test results with crop characteristics and requirements thus recommending supported crops on that soil as seen in **figure: 5.4** below



Figure: 5.4 Soil Crop Matching Tool Results

The figure 5.4 above shows a soil crop matching tool results. Before soil crop matching, the tool first carries out a soil analysis on the results entered to know the physical/chemical analysis of the soil as seen above the table of recommended crops. After matching with the crop requirements the system recommends supported crops on that soil which are listed in the table above. The system also calculates the required amount of seeds to be sown on the area entered in the system by the user, it also calculates the anticipated crop yields using the area entered into the system by the user and it also calculates the estimated market value of yields after harvesting the crop.

5.4 Yields Calculator

The screenshot displays the 'SOIL-CROP ANALYSIS SYSTEM' web interface. At the top, a banner features various agricultural images and the tagline 'Providing solutions to farmers'. Below the banner, a navigation bar includes links like Home, Soil Test Analysis, Fertiliser Calc, and others. The main content area is titled 'Crop Yields Calculator' and contains a form for calculating crop yields. The form includes fields for selecting a crop (Ground nuts), total area of land (6 acres), specified mean annual rainfall (1150 mm), and various soil parameters (Nitrogen, Phosphorous, Soil pH, Soil Organic Matter Content, Sulphates, Potassium, Soil Moisture Content, and Soil Texture). A 'Calculate Yields' button is located at the bottom of the form. The footer of the page shows the copyright information for the Faculty of Computing and IT at Makerere University Kampala.

SOIL-CROP ANALYSIS SYSTEM

Welcome Peter Bamuhigire [Logout](#)

Home | Soil Test Analysis | Fertiliser Calc | Fertiliser Info | Soil-Crop Matching | Yeild Calc | Crop Info | Results | Administrator

Crop Yeilds Calculator .

Fill in the Table Below to calculate yeilds. Please note that crop prices are dependant upon season and market conditions.

Select a Crop :	Ground nuts	Location of Soil :	iganga
Total Area of Land (acres) :	6	Annual Rainfall (Select District)(mm) :	iganga
Specified Mean Annual Rainfall (mm) :	1150	Soil Texture (%) :	Sand 30 Loam 50 Clay 20
Nitrogen (%) :	34	Sulphates (mg/kg) :	23
Phosphorous (mg/kg) :	33	Potassium (mg/kg) :	99
Soil pH :	6.3	Soil Moisture Content (%) :	21
Soil Organic Matter Content(%) :	12		

[Calculate Yields](#)

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Figure: 5.5 Yield Calculator

The *figure 5.5* above is used to calculate crop yields of a given crop using information filled in the textboxes and information stored in the system. The user selects a crop from the drop down menu to calculate its estimated crop yields. The user specifies the size of area where he/she is going to plant the crop by entering it in the total area of land textbox. After filling in all the required information, the user clicks 'Calculate Yields' button to calculate the yields of the selected crop under optimum conditions and also using information entered in the textboxes. The results a shown in **figure: 5.6** below

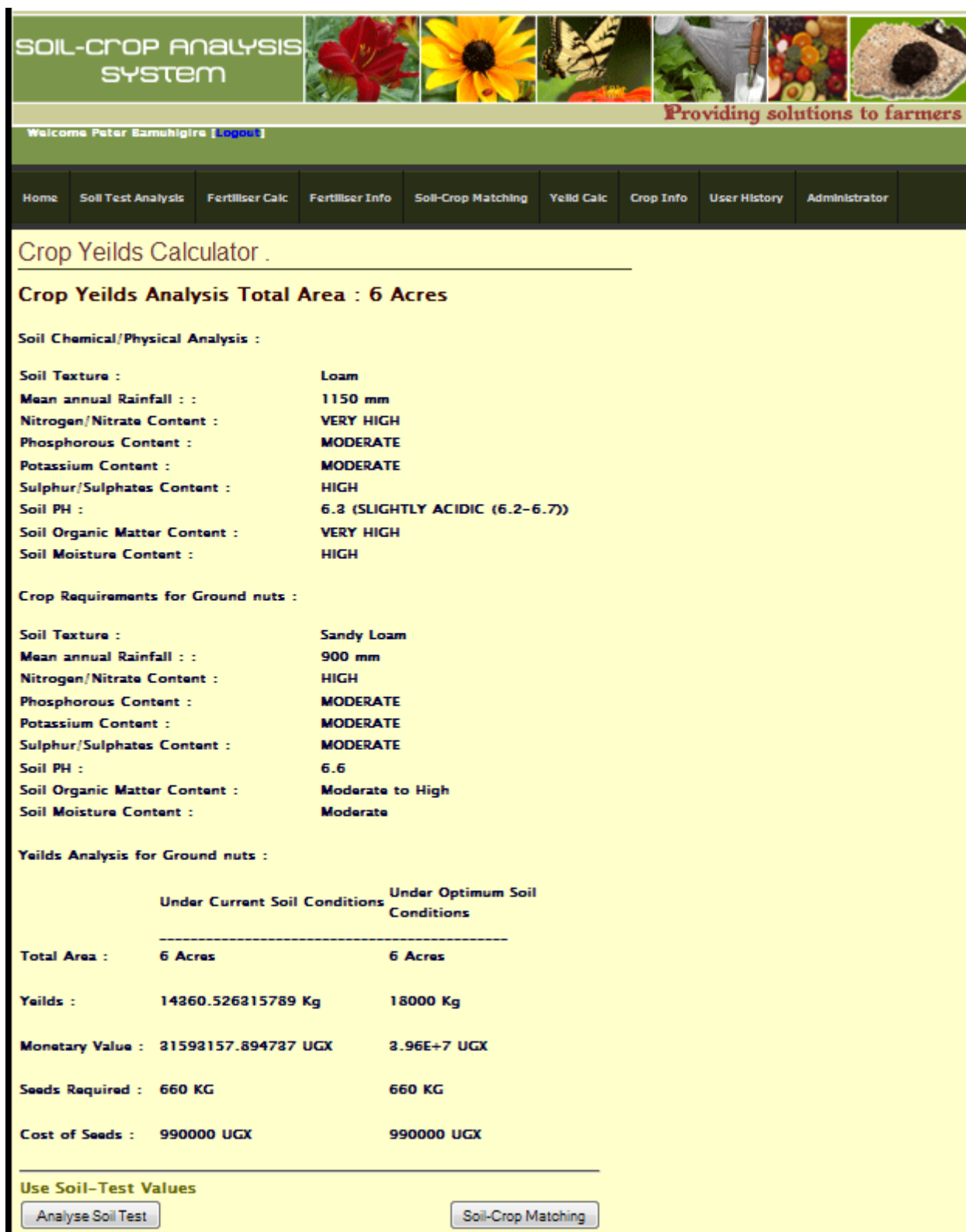


Figure: 5.6 Yield Calculator Results

5.5 Results Page

SOIL-CROP ANALYSIS SYSTEM

Providing solutions to farmers

Welcome Peter Bamuhigire [Logout](#)

Home | Soil Test Analysis | Fertiliser Calc | Fertiliser Info | Soil-Crop Matching | Yeild Calc | Crop Info | Results | Administrator

User Results.

This page displays previous soil test results You have entered into the system..

Date	Location	Area
2009-06-01	Namulonge A	3.56 Acres
2009-06-01	Kawempe NAADS	1.05 Acres
2009-06-01	Mbarara Demonstration Farm	3.58 Acres
2009-06-01	Soroti	3.50 Acres
2009-06-06	Kalinabiri	3.02 Acres
2009-06-09	Source of the Nile	24.25 Acres
2009-06-12	Nabigalo	2.54 Acres
2009-06-17	Namuga	2.10 Acres
2009-06-19	Sagabulo	20.58 Acres
2009-06-24	Kikoni	1.52 Acres

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Figure: 5.7 Results page

The *figure 5.7* above is used to view user results. Every time a user carry's out an analysis, the system keeps a record of it in the system database. The user results page shows stored analysis's carried out by that particular user. The user has the option to select any analysis carried out depending on which date it was carried out in order to view data that was used to make the analysis and also to use the same data to carry out another process or function.

Chapter 6

6.0 Testing, Deployment & Presentation Of Findings

6.1 System Testing

The developed system underwent various methods of testing that have been evident elsewhere on software development projects for example; unit tests, integration tests, system tests and acceptance tests. Accordingly, the original Use Case was tried in the finished application and was performed as defined in the Use-case descriptions.

- 6.1.1 **The Unit tests:** These are tests of individual classes or group of classes and were typically performed by the programmers. As the project team traversed through the coding stage, every finished module would be tested in order to enable early debugging at a lesser cost.
- 6.1.2 **The integration tests:** These tests were carried out to integrate components and classes in order to verify that they cooperate as specified. In this case we had components of the system developed in different languages like PHP, HTML, Flash and a MySQL database; thus all components were successfully integrated into one system.
- 6.1.3 **The system test:** This test helped the development team, to view the system as a “black box” and also validated that the system consisted of the end functionality expected by the user.
- 6.1.4 **The acceptance test:** This kind of test was conducted by the soil tester at the Faculty of Agriculture in the soil department in order to verify that the system satisfies the end user and functional requirements. In this case the user was given the system to enter his soil test results and carry out a soil analysis, after which he had to give a feedback about the system and its functionality.

6.2 Deployment

The deployment of the system is the actual delivery, including the documentation, which in this case comprises of a user manual.

In addition to the user manual, a deployment diagram is provided below showing the physical architecture of the SCAS. This system can be deployed in any computer with WAMP, a network connection, Graphical user interface and note that some services require a printer and digital camera or scanner to fulfill there functionality.

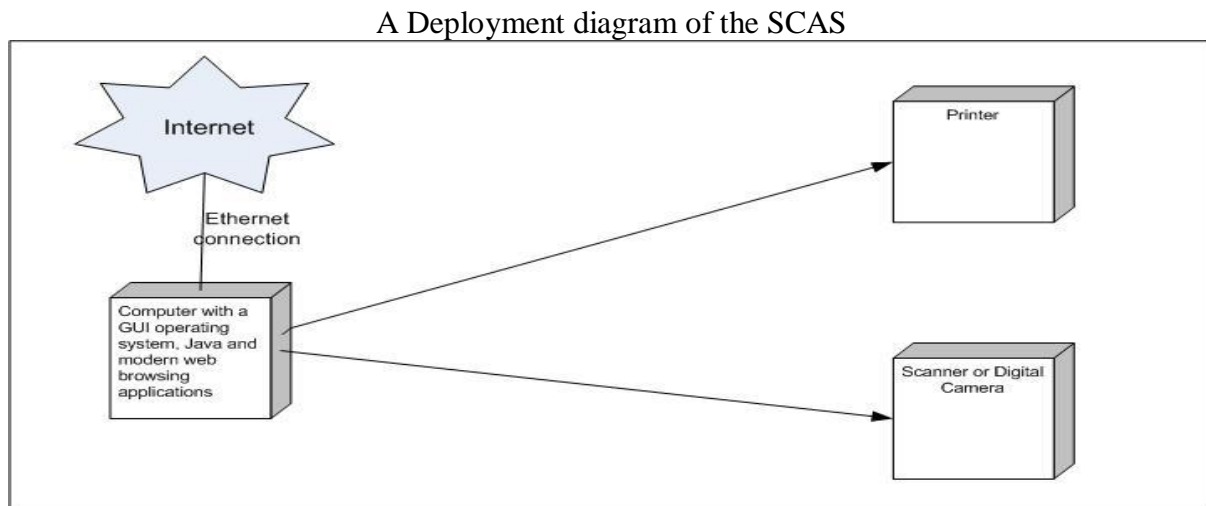


Figure: 6.1

6.3 Presentation of Findings

The report was written after carrying out an analysis of the soil analysis process currently existing in the country. It involved discovering the weaknesses of the existing system, its way of operation, strengths so that an improvement on it would be carried out. Different kinds of research were looked at and this is shown in the literature review section of the report. The intension was to expose what other people and countries did in implementing SCAS systems and the methods they used for implementation without their weaknesses. The group members decided to visit the Department Of Soil Science, Faculty of Agriculture Makerere University.

From the analysis of the response from the Department Of Soil Science, Faculty of Agriculture Makerere University, it was concluded after having an interview and presentation of the system to staff, that the system is viable and can be relied on during soil analysis. The system can also be accessed from anywhere provided one has access to the internet. The staff also supported the idea of introduction of the system to support soil analysis in agriculture.

6.4 Importance of the Study

This system if implemented will help fasten the soil analysis process of soils from different parts of the country and to reduce manual storage of soil analysis information in the agriculture sector. It will further enable researchers, farmers and scientists to apply analyzed soils with the view of enabling them make decisions on the ideal crops supported by the soils.

It will also be able to suggest solutions to nutrient deficiencies in the soils such as what fertilizers to apply and in what quantities. This will enable farmers to make decisions that will help increase their yields when they apply the right fertilizers and grow the right crops in their soils thus providing a solution to the majority of the farmers who suffer from chronically low yields.

Chapter 7

7.0 Summary, Conclusion and Recommendations

7.1 Introduction

The chapter discusses achieved objectives, recommends and makes a conclusion to the project report.

7.2 Discussion

The project was successful in implementing the objectives stipulated in earlier chapters. The SCAS offers a number of benefits to the users; farmers or researchers can automatically register, update and view records where as the system administrator can manage and configure the various parameters of system functionality. In addition the system can also authenticate the users, display the status of a crop yields and total costs and generate reports.

7.3 Work Plan Of The SCAS

This sub-section details how the project team organized themselves; in order to successfully execute the various activities that made the project a success.

7.3.1 Project Time-Line

This was the period spent doing the project and the various activities plus the dates on which they were executed;

The project took a total of 66 days and the following is an account of how time was divided amongst the different activities that were carried out in the process of developing this system.

#	Task	Dependencies	Days	Time
1	Idea generation (Concept paper)	-	4	06-Mar/10-Mar
2	Project proposal	1	13	17-Mar/29-Mar
3	Data Collection	2	5	31-Mar/4-Apr
4	Data Processing	2	8	31-Mar/7-Apr
5	Feasibility Study	3	3	5-Apr/7-Apr
6	Requirements analysis	4	3	8-Apr/10-Apr

#	Task	Dependencies	Days	Time
7	Design	5,6	4	10-Apr/13-Apr
8	Programming / Construction	7	13	14-Apr/28-Apr
9	Testing	8	2	29-Apr/30-Apr
10	Documentation (Final Report)	6,7,8	10	1-May/10-May
11	Presentation Rehearsals	10	9	23-May/31-May
12	Final Report / Project Presentation	11	1	1-Jun
13	Project completion Milestone	11		0
Days Spent				66 days

Table: 7 Project Time-Lines

7.3.2 Equipment Used To Carry Out the Project

The study used the following tools extensively through out the project:

- Project website
- Project mailing lists
- Computers
- Macromedia Flash, Dreamweaver
- Notepad ++ (Text editor)
- Microsoft Word, Visio, Project Management
- The Internet

7.4 Future Improvements Of The SCAS

In order to improve and increase the use of Information Technology Solutions in agriculture, there is a need for further research in order to:-

- Come up with more advanced software that can remotely connect all the other remote major towns in districts round and globally.

- Enable a farmer or researcher to use the internet, log in to this system and remotely analyze test results and recommend suitable crops and get all the information they need say, total costs and yields.
- Other demands may arise with the ongoing evolution and use of the system.

7.5 Limitations of the Study

The study although successful, had a few encounters during the design process. The greatest limiting factor was the little time that was allocated to the project because it was done amidst lectures. The time was not enough to enable the group members incorporate into the system all that would be required. There was also a shortage of funds to help the group members do the work successfully and it affected the project most of the time.

7.6 Summary

The study demonstrated how a short text specification of a system can be modeled in analysis, expanded and detailed into a design model, and finally implemented and programmed in PHP, HTML and JavaScript.

The various parts of this study were designed by group members who made every effort to work in the same manner they would have done on an actual business project.

And though the different phases and activities might seem separate and; to have been conducted in a strict sequence, the work is more iterative in practice.

7.7 Recommendation

This is the normal way of building an object-oriented system like the SCAS and we recommend the usage of this application in agricultural sector due to its consistency and limited system resource capability.

However, for farmers who cannot access the internet or who are computer illiterate, we recommend that the Ministry of Agriculture in conjunction with the ICT ministry should station researchers with cardinal knowledge of the SCAS in different parts of the country who can always help out the farmers to analyze their tests using the system.

Else, the farmers can make contributions and buy a soil kit that would help them carry out their soil tests too and it can be got from the faculty of Agriculture Makerere University at 100 US dollars.

7.8 Conclusion

A soil analysis is used to determine the level of nutrients found in a soil sample. As such, it can only be as accurate as the sample taken in a particular field. The results of a soil analysis provide the agricultural producer with an estimate of the amount of fertilizer nutrients needed to supplement those in the soil. Applying the appropriate type and amount of needed fertilizer will give the agricultural a more reasonable chance to obtain the desired crop yield.

Therefore the system developed will be able to provide a basis for fertilizer recommendations for a given crop and evaluate the fertility status of the soil and plan a nutrient management program.

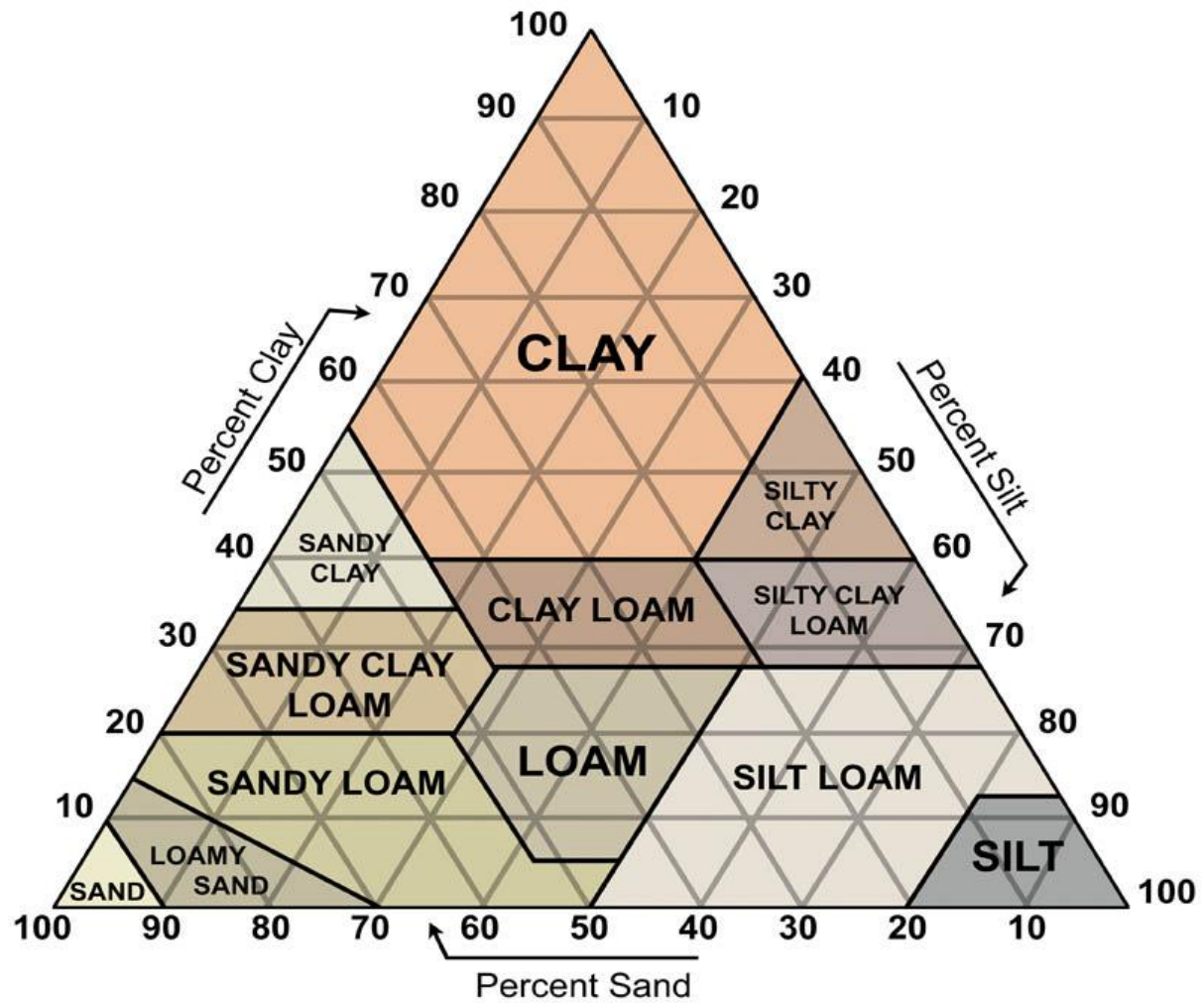
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Appendices

Appendix: 1

A snap shot of a Soil texture triangle



Appendix: 2

Validation Form Code

```
<script type='text/javascript'>

function formValidator(){
    // Make quick references to our fields
    var firstname = document.signupform.firstname;
    var lastname = document.signupform.lastname;
    var password = document.signupform.password;
    var phone = document.signupform.phone;
    var username = document.signupform.username;
    var email = document.signupform.email;

    // Check each input in the order that it appears in the form!

    if(isAlphanumeric(username, "Please enter your username" )){
        if(isAlphanumeric(password, "Please enter your password")){
            if(isAlphabet(firstname, "Please enter only letters for your first name")){
                if(isAlphabet(lastname, "Please enter only letters for your last name")){
                    if(emailValidator(email, "Please enter a valid email address")){
                        if(isNumeric(phone, "Please enter a valid phone number")){
                            return true;
                        }
                    }
                }
            }
        }
    }

    return false;
}

function isEmpty(elem, helperMsg){
    if(elem.value.length == 0){
        alert(helperMsg);
        elem.focus(); // set the focus to this input
        return true;
    }
    return false;
}

function isNumeric(elem, helperMsg){
```

```

        var numericExpression = /^[0-9]+$/;
        if(elem.value.match(numericExpression)){
            return true;
        }else{
            alert(helperMsg);
            return false;
            elem.focus();
        }
    }

    function isAlphabet(elem, helperMsg){
        var alphaExp = /^[a-zA-Z]+$/;
        if(elem.value.match(alphaExp)){
            return true;
        }else{
            alert(helperMsg);
            return false;
            elem.focus();
        }
    }

    function isAlphanumeric(elem, helperMsg){
        var alphaExp = /^[0-9a-zA-Z]+$/;
        if(elem.value.match(alphaExp)){
            return true;
        }else{
            alert(helperMsg);
            return false;
            elem.focus();
        }
    }

    function lengthRestriction(elem, min, max){
        var uInput = elem.value;
        if(uInput.length >= min && uInput.length <= max){
            return true;
        }else{
            alert("Please enter between " +min+ " and " +max+ " characters for username");
            elem.focus();
            return false;
        }
    }

    function madeSelection(elem, helperMsg){

```



```

        if(elem.value == "Please Choose"){
alert(helperMsg);
return false;
elem.focus();
        }else{
                return true;
        }
}
function emailValidator(elem, helperMsg){
        var emailExp = /^[w\-\.\+]+\@[a-zA-Z0-9\.\-]+\.[a-zA-z0-9]{2,4}$/;
        if(elem.value.match(emailExp)){
                return true;
        }else{
alert(helperMsg);
return false;
elem.focus();
        }
}
</script>

```